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Jurors' perceptions of forensic science expert witnesses

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Experience, Qualifications, Testimony Style and Credibility

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Abstract: The judicial system calls upon expert witnesses to testify in court when complex or specialized knowledge, beyond that of the lay person, is needed to interpret the evidence. Previous research has indicated that particular traits of the expert witness influences their credibility in the eyes of the jury, however most of this research has been undertaken using mock jurors. In contrast, this study investigated the perceptions of real jurors. In particular, the research work focused on the juror's perception of the forensic scientists' expertise and credibility during testimony in homicide cases. Data was gathered from jurors after they had completed jury duty in one of nine homicide trials using both questionnaire (n=29) and direct one to one interviews (n=22). The jurors defined what they thought an expert witness was and what attributes were important in a forensic scientist. Jurors suggested that the expert witness's education and years of experience were more important than certification or laboratory accreditation. The jurors' perceptions of the credibility of the expert was based upon the academic qualifications of the expert, the confidence they portrayed in answering the questions ask of them, their demeanor and their status of being government employee.

The use of narrative language and demonstrative aids by the forensic science expert witness to explain the evidence was explored. Jurors described a deeper understanding as a result of such testimony and the narrative testimony of the witness was reported to be a key factor in the juror's acceptance that the witness was credible.

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Original Research Article

Title:

Jurors' perceptions of Forensic Science Expert Witnesses: Experience, Qualifications, Testimony Style and Credibility

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*Highlights (for review)

- Jurors rank expert's experience & education higher than lab accreditation
- Expert confidence and demeanor influence perception of credibility for jurors
- Use of Demonstrative aids increase expert's credibility

Original Research Article

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Jurors' perceptions of Forensic Science Expert Witnesses: Experience, Qualifications, Testimony Style and Credibility

Abstract

The judicial system calls upon expert witnesses to testify in court when complex or specialized knowledge, beyond that of the lay person, is needed to interpret the evidence. Previous research has indicated that particular traits of the expert witness influences their credibility in the eyes of the jury, however most of this research has been undertaken using mock jurors. In contrast, this study investigated the perceptions of real jurors. In particular, the research work focused on the juror's perception of the forensic scientists' expertise and credibility during testimony in homicide cases. Data was gathered from jurors after they had completed jury duty in one of nine homicide trials using both questionnaire (n=29) and direct one to one interviews (n=22). The jurors defined what they thought an expert witness was and what attributes were important in a forensic scientist. Jurors suggested that the expert witness's education and years of experience were more important than certification or laboratory accreditation. The jurors' perceptions of the credibility of the expert was based upon the academic qualifications of the expert, the confidence they portrayed in answering the questions ask of them, their demeanor and their status of being government employee.

The use of narrative language and demonstrative aids by the forensic science expert witness to explain the evidence was explored. Jurors described a deeper understanding as a result of such testimony and the narrative testimony of the witness was reported to be a key factor in the juror's acceptance that the witness was credible.

Key Words

Forensic Science, Expert Witness Credibility, Education, Jury Decision Making, Criminal Trials, Expert Testimony

Introduction

How jurors perceive expert witnesses who testify is an area of research interest to judicial stakeholders. In an adversarial system, such as that in the United States, a persuasive witness could change the course of the trial and potentially have a significant influence on jury decision making. Understanding what factors and attributes in the expert witness translate to credibility in the juror's mind is therefore valuable information for judges, attorneys and forensic scientists.

Early research on witness credibility investigated if witness's attire, whether they wore glasses, carried a briefcase or for women, if they wore their hair up or down influenced how jurors judged the knowledgeability of the expert (Tanton, 1979). Previous research in this area has focused on perceptions of mock jurors have on expert witnesses in simulated trial experiments. One such study found that as the expert witness's experience level and status increased so too did the juror perceptions of their expertise (Swenson et al., 1984). A more recent study which investigated the influence of scientific validity behind the evidence, witness expertise and the witness's use of technology on jurors. This study found that as the trial simulations became more ecological (closer to a real trial) there was an increase in the influence of the expert's experience on the perceived reliability of the evidence and that neither the scientific validity of the evidence or the expert's use of technology had an influence on jurors perceptions (Koehler et al., 2016).

Other studies have examined how judges perceive the credibility and persuasiveness of expert witnesses. When asked to rank in order of importance the experience, education, publications or previous expert testimony the vast majority of judges ranked experience as most important followed by education whereas publications and prior testimony had very little influence on perceived credibility (Shuman et al., 1994). Another study of judge's perceptions of expert witness credibility found that the communication style of the expert was most important. Judges found expert witnesses to be more persuasive when they spoke clearly, avoided the use of jargon and technical terms and who appeared impartial (Freckelton et al., 1999).

Brodsky *et.al* reviewed the literature and found that juror's descriptions of credibility of expert witnesses could be condensed into four main categories; likability, believability, trustworthiness and intelligence (Cramer et al., 2009) where likability was found to be the most

significant factor which influenced the juror's perception of trustworthiness of the expert witness (Cramer et al., 2009).

A disadvantage of the current body of research however is that most has been based primarily on mock juries, and in a limited capacity on real juries. Previous research on the perceptions of real jurors after real trials where physicians, accountants, biochemists and engineers testified as expert witnesses found that jurors placed more weight on testimony of witnesses who did not use technical language and offered firm opinions (Hastie, 1993, Champagne et al., 1991). The available literature also indicates that real jurors consistently find the expert's professional experience to be the greatest factor in determining their credibility over factors such as lack of bias or impartiality and academic education (Blackwell and Seymour, 2015, Sundby, 1997, Schutz, 1997, Schweitzer, 2016).

It has also been shown that jurors were more likely to find expert witnesses credible when they used demonstrative aids such as charts (Gutheil, 2000). When jurors did not understand the expert's testimony, they have been shown to take heuristics, or mental shortcuts relying on the appearance and communication skills of the expert as a measure of their credibility (Rosenthal, 1983).

It is highly likely that the credibility of the expert witness is based on multiple factors rather than one single factor. This research explored this area in some depth and with real jurors rather than under conditions of simulation. The study attempted to answer the research question, "What factors influence how jurors judge the credibility of forensic science expert witnesses?"

Methodology

Participants

The sample population for this study were jurors who heard forensic science testimony in homicide trials in the State of Maine. Maine is the most northern state on the east coast in the United States of America and has a population of 1,335, 907 (Bureau, 2017). There were 29 jurors who participated in the survey and of these, 22 participated in the follow-up phone interviews. Males made up 45% of the survey participants and 50% of the phone interviewees.

The jurors ranged in ages from 18 to 65+ with the average age for phone interviewees being in the 45-54 age category. Of the jurors who participated in the interviews, 86% reported being married, in common law partnerships, civil partnerships or cohabiting and 52% reported having earned a 4 year undergraduate degree or higher.

Data Collection

The data collection was carried out over a 24 month period from July 2014 to July 2016. The data collection tools (survey and interview questions) were developed and the judicial approval was sought and received by the Chief Justice of the State of Maine (U.S.A) Superior Court. The researcher attended nine trials, observed and took field notes when forensic science testimony was given by experts. The only experts observed were those who were called by the prosecution as these were the only forensic science witnesses whose appearance date at the trial was scheduled in advance, making the testimony observation possible. After the verdict was delivered the jurors remain empaneled in Maine for another 30 days. After this time a survey was posted to all jurors and alternate jurors. Jurors (N=29) returned the survey to the researcher and a subset of these jurors (N=22) participated in phone interviews. All jurors who responded were included in the sample. To ensure juror confidentiality and anonymity, jurors were given pseudonyms. Pseudonyms of individuals who were jurors in the same trial were given names that began with the same letter. The data were then organized and analyzed. Figure 1 outlines the research process.

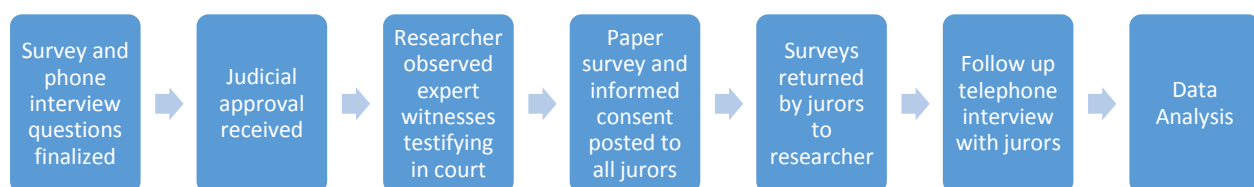


Figure 1: The Overall Research Process

The Researcher

The interviewer was female, worked as an assistant professor and had no prior relationship with the participants. The interviewer held a Master's degree in forensic science and

had worked as a latent print examiner (full time and later as a consultant) for 14 years. The participants were not informed of the interviewer's forensic science background.

The researcher was interested in addressing the gap in the literature highlighted in the United States National Academy of Science, National Research Council report "Strengthening Forensic Science in the United States: A Path Forward (2009)" where it was reported that "jurors use and comprehension of forensic evidence is not well studied" (National Research Council, 2009).

Researcher bias is an inherent concern in qualitative research, where the researcher themselves analyses and interprets the data and forms conclusions. Bias was minimized in this study by developing a series of structured interview questions and making these questions the backbone of the interview. In phenomenological research, such as this, as well as all qualitative research, it is important to allow the subject being interviewed to express freely their experience of the phenomenon and that was done throughout this work. When jurors veered away from the question asked the resultant side stories are also of great value and provide a rich vein for gaining understanding of the experience of the juror.

Instrumentation and Data Analysis

Quantitative Data

The quantitative data were organized, stored and analyzed using Microsoft Excel (2013). The data in the frequency tables and the charts were generated in Excel and the more advanced statistical calculations were carried out using IBM Statistical Package for the Social Sciences (SPSS, version 21). SPSS was used to determine if there were correlations between variables and their level of significance.

Qualitative Data

The vast majority of the qualitative data came from phone interviews with 22 jurors. Phone interviews were carried out using Skype® (version 7.33.01.104) with the plug-in Vodburner® (version 1.1.0.203). Vodburner recorded the calls and these were transcribed using an online service. The phone calls lasted from 32 minutes to 72 minutes and the length depended

on the responses the jurors gave. The interviews were structured by the particular questions that were asked of each juror, but jurors were given flexibility to speak for as long as they needed to. A great deal of data was generated by allowing this free flow of information. The questions asked during the phone interviews (Appendix B) gave a deeper meaning to the quantitative data and helped answer the research question posed at the beginning of this research.

The process of data analysis in this phenomenological phase was a cyclic one, meaning that the analysis of statements and coding of key phrases was constantly evaluated and re-evaluated. This was done by the primary investigator and reviewed by a second researcher. In order to minimize bias while undertaking the iterative process of developing themes, the primary investigator made a conscious effort to bracket any *epoché* (to suspend judgement) held regarding the jurors' perceptions of factors that influence decision making (Moustakas, 1994).

The qualitative data were organized in Nvivo (version 11) and analyzed in four steps. The first step was to organize the jurors' responses by the question asked during the interview. This was done by making each question a node. This grouped all the responses to the same question and allowed a general sense of the jurors' perceptions regarding the expert witnesses at the trials to be formed.

The next step was to organize the jurors' responses into broad categories based on the goals of the research. Given the gap in the literature for research involving real jurors, all the factors that influence jurors' perceptions of expert witnesses were not known at the outset of this research. It was essential for the researcher to analyze the qualitative data for new and emerging themes.

Determining what is an adequate sample size in qualitative research is not well defined. It depends on the number of interviews as well as the quality of the data. Qualitative research is often measured in terms of data saturation. This is the point in the research where there are no new themes or perspectives related to the research question (Brod et al., 2009) and the literature suggest this can happen as early as 6 in-depth interviews and on average with 12 interviews (Guest et al., 2006). The 22 in- depth interviews in this particular study and the analysis of the themes and repeating juror perspectives suggest data saturation was achieved.

Methodology

A parallel convergent exploratory mixed methods design (Figure 2) was used to attempt the answer the research question. This type of mixed method research fit the confines of this study as both the survey and interview questions needed to be judicially approved in advance of contacting the jurors. As all of the factors which might influence a juror's perception of an expert witness were not known at the beginning of this study fell within the exploratory category. This research approach involved collecting the quantitative and qualitative data within 1-2 weeks of each other (parallel convergent), analyzing the data and interpreting the qualitative and quantitative data simultaneously.

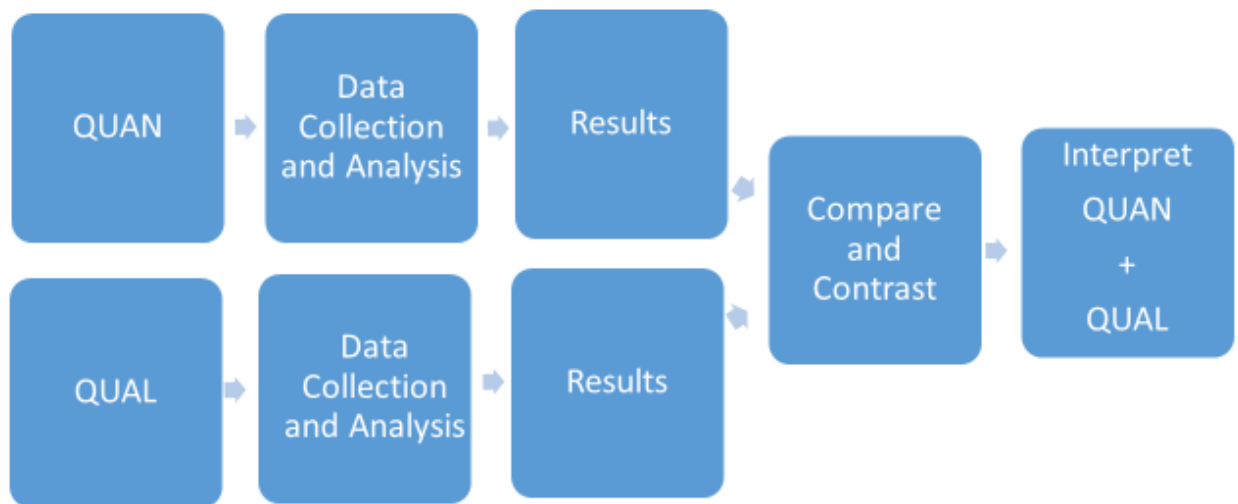


Figure 2: Parallel Convergent Mixed Method Approach

Results

During the study, a set of questions was asked which specifically related to the jurors' perception of the forensic science witnesses. These included both survey (Appendix A) and

interview questions (Appendix B). The purpose was to elucidate responses which would provide information relating to how the jurors' valued both the expertise and experience of the expert and to seek information on factors which might influence their perceptions of the expert's credibility.

Jurors' Definition of an Expert Witness

The jurors defined an expert witness in multiple ways but many definitions contained common descriptors such as '*knowledgeable*' and '*specialized*' and as someone who had '*received training*'. A few jurors indicated that a certain amount of experience was necessary to truly be considered an expert witness. "Justin" described a forensic science witness as:

"Somebody ...who has training. To me it's important to have a college background, scientific background. If you're going to be analyzing data, you need to understand statistics and also processes and knowing what procedures are and following them. Just because somebody takes a six weeks course doesn't really, to me, qualify them as an expert."

and "Gail" described experience as important:

"somebody with a lot of experience, has been working in it for quite a while".

For some jurors, credentials and certifications were an important part of the definition of an expert witness. "Gillian" expected forensic science experts to have:

"licenses or certifications pertaining to that field"

and "Matthew" said experts should have:

"credentials or certificates of competency".

Qualifications, Training and Certifications of an Expert Witness

One question on the survey question (Appendix A, question 4) asked jurors (n=25) to rate, in order of importance the qualifications and background criteria for an expert witness. The results combined across all 25 jurors are presented in Figure 3.

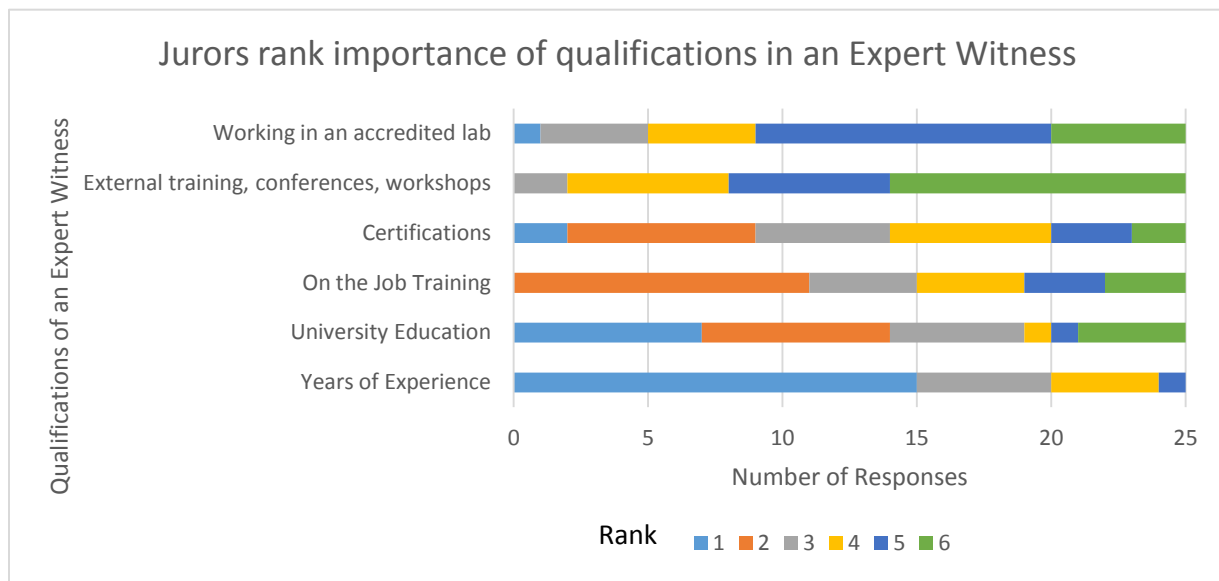


Figure 3: Jurors’ interpretation of the importance of qualifications in an expert witness (Rank: 1= Most Important, 6= least important)

There was no one qualification that all jurors found important. Years of experience was ranked in the top 3 by 80% of the jurors, university education was ranked in the top 3 by 76% of the jurors and on the job training was ranked in the top 3 by 60% of the jurors. Less important to the jurors was whether the expert worked in an accredited lab or the expert’s external training. 80% of the jurors ranked “working in an accredited lab” in the lower three positions and 92% of jurors ranked external training in the lower 3 positions. (Table 1).

Table 1: Importance of qualifications in an expert witness

	Rank in importance		
	Most	Least	
	1&2	3&4	5&6
University Education	14 (56%)	6 (24%)	5 (20%)
On the Job Training	11 (44%)	8 (32%)	6 (24%)
Certifications	9 (36%)	11 (44%)	5 (20%)
Years of Experience	15 (60%)	9 (36%)	1 (4%)
Working in an accredited lab	1(4%)	8(32%)	16(64%)
External training	0	8 (32%)	17 (68%)

(red = below 25%; orange= >30-59%; green =>60%)

The data may have been influenced by the jurors' perceptions of higher education, where over 80% ranked experience and education high irrespective of whether they themselves had attained education beyond the high school level. A Pearson correlation coefficient was calculated for university education and years of experience. There is moderate inverse correlation between a juror's ranking of university education and their ranking of years of experience ($r = -.552$, $N=25$, $P=.01$). Jurors who tended to rank university education high also tended to rank years of experience low, and vice versa. This data is illustrated in Table 2.

Table 2: Correlations of the ranking by Jurors of an expert witnesses qualifications

	University Education	On the job training	Certifications	Experience	Working in an accredited lab	External Training: Conferences/ workshops
University Education	1	-.299	-.051	-.552**	-.196	.163
OJT	-.299	1	-.511**	-.060	-.127	-.155
Certifications	-.051	-.511**	1	-.189	-.166	-.078
Experience	-.552**	-.060	-.189	1	-.231	.300
Working in an accredited lab	-.196	-.127	-.166	-.231	1	-.237
External training: conferences/ workshops	.163	-.155	-.078	-.300	-.237	1

**Highlighted areas indicate correlations which are significant at the 0.01 level (2-tailed)

The same was true for the correlation between on the job training and certifications ($r = -.511$, $N = 25$, $P = 0.01$). Jurors who ranked on the job training high tended to rank certifications low. This appears to indicate that jurors either put weight on formal education of the expert witnesses, such as certifications and university education and placed less value on the job training and years of experience, or vice versa.

In response to the interview question “Which is more important in an expert witness, qualifications, such as education or certifications or years of experience?” (Appendix B, question 3) the majority of jurors, 63%, stated that years of experience was more important in an expert witness than qualifications (Figure 4) supporting the data derived from the paper survey.



Figure 4: Jurors’ evaluation of the importance of formal qualifications vs. years of experience

Jurors thought experience was the most important factor in an expert witness and explained that although education and certifications are important for a forensic scientist, they felt that it was the application of this knowledge (through job experience) that led to expertise. “Amy” stated:

“I think there are some people who can get many certifications and take many courses and classes, but they can't actually apply it and have never applied it. I think there are people who have developed significant experience in the subject matter from just seeing, doing, being around it, being around other people”.

Jurors described the value of experience in terms of the variety of evidence types a forensic scientist might be called on to analyze. “Amy” said that a person with experience would be better than a person with only qualifications when the evidence was complex or outside of what might be expected:

“(forensic scientists) having a sense of what the norm would be and things that would not necessarily be the norm.”

“Dana” described the benefit of experience to the forensic scientist as:

“Highly qualified people do not necessarily have the vast experience to know what is average or extraordinary or usual”.

“Dorothy” felt experience allowed the scientist a range of approaches when examining evidence:

“because every case is a little bit different, and I think that there's more flexibility in experience. (Evidence is) not as standard as stuff you get from the textbook”.

Some of the jurors related the value of experience back to their own professions and job experience. There was an understanding among jurors that forensic science as a profession cannot be learned solely from books. “Lloyd” said;

“I'm an accountant. When I started accounting, even though I had learned all this stuff, actually seeing it in practice the first time ...things are a little different than what you see in the book. You have to be able to recognize that. I would say that experience is probably, with the proper qualifications or the training, experience would be more important than the qualifications”.

“Larry” explained the value of experience by relating it to a life event:

“I would say years of experience, and here's a good example. My wife was seeing a medical specialist and saw him for several years, and he had qualifications. He had certificates and he had fancy diplomas, and he lost his medical license because he didn't know what ... he was doing. I would much rather, someone in a very serious professional field, I would much rather have someone that had a lot of experience and was competent.”

The challenge for new forensic scientists in qualifying as an expert in court will be to describe their qualifications and also how they have learned the discipline through supervised casework or other internal training. “Harold” explained:

“For example, if someone were soon out of college, I don't know that they're going to be an expert witness but they do have the necessary education to get them there. Some of those things go hand in hand. Experience is very important but their upbringing or background enters into it as well. I would think that a journeyman so to speak would be working with an expert witness and would become an expert witness over time based on both education and then experience in the career.”

A few jurors described the connection between experience and qualifications. To gain experience you need qualifications and to gain credentials you need experience. Certification in many of the different forensic science disciplines requires the scientist to have a certain minimum number of years of experience, so it is true that credentials such as certifications require experience as well. “Ann” said:

“it's hard for me to almost differentiate them because my assumption would be if they're credentialed in anyway, that that process means that they do have experience. I guess I would say credentials, assuming that that comes along with some kind of procedure, or protocol, before they are credentialed that would involve experience.”

“Gillian” also felt that experience and qualifications went hand-in-hand:

“I think it varies because, well, personally I say both in order gain the qualifications you have to have the experience”.

For the most part the jurors valued both experience and the formal qualifications of the expert witnesses. “Grace” described why she thought both education and experience were important in an expert:

“I think both are important but a person wouldn't be reliable if they didn't have the proper qualifications and I think that's just the standardized way of demonstrating someone's expertise in the field is usually if they have a certain credential there. They're passing the test but they're also certified at that level by having years of experience. Someone doesn't just pass the test and become a Medical Examiner. They're supervised and they're given feedback. To me, the qualification supersedes experience because it includes experience.”

When speaking of the importance of qualifications jurors focused on the value of foundational knowledge needed by a forensic scientist that the jurors described should be based on education and other credentials. “Justin” described expertise in terms of his own experience as an engineer:

“I guess for me qualifications. I'm an engineer and the only way that I could get my professional engineering license was by having a certain number of years of experience. Then I'd have to have other professional engineers sign off that they've observed me and witnessed my performance. I'd have to have a certain amount of education in order to pass. I think qualifications is higher than experience”.

Judging the Credibility of the Forensic Science Expert Witness

Jurors were asked in the survey to rate the credibility, in their view, of the expert witnesses that they watched during the trial. The jurors who participated in the follow-up phone interviews were asked to describe how they determined if an expert witness was credible. Jurors rated all the expert witnesses they watched as being credible. Figure 5 illustrates the breakdown of the evaluation of credibility across all of the expert witnesses. 99% of the jurors felt that the expert witnesses were either very credible (54%) or Credible (45%).

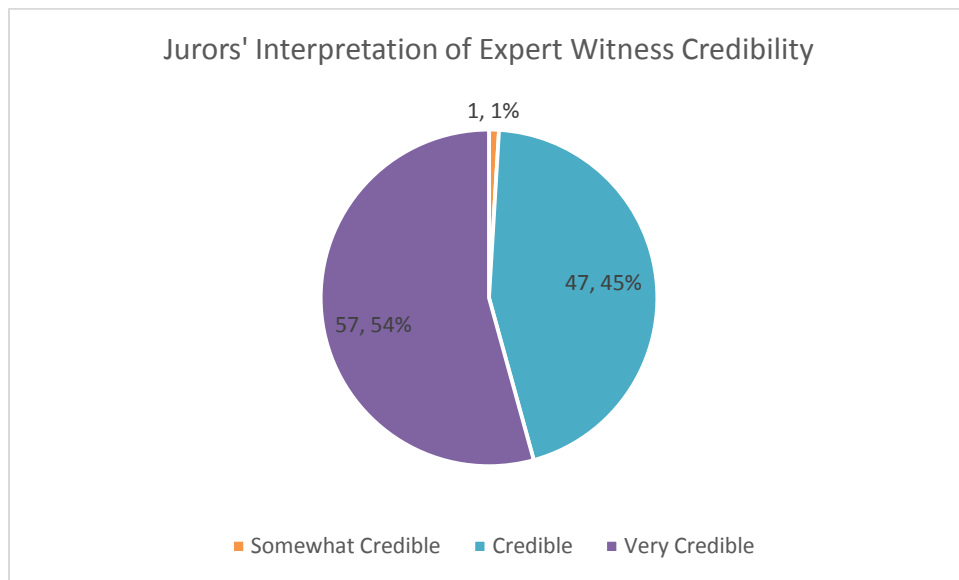


Figure 5: How jurors rated credibility of all expert witnesses who testified at their trial

Qualifications

Jurors described their view of the expert witnesses' credibility based on the experts' qualifications. Each time a forensic science expert witness testifies in the State of Maine they answer questions asked by the attorney who called them. This gives the court an opportunity to

decide if the individual is an expert for the purposes of the trial. This process gave credibility to the expert witnesses. “Grace” explained:

“I believe that they were credible when they went through and introduced their background. They wouldn't just come up and start answering questions. They would begin by ... Well, actually it was from a question. The first question would be describing your background or qualifications or credentials. When they described that aspect, that's what sold me in trusting what they had to say.”

“Lloyd” stated how he determined credibility of an expert witness as:

“the lawyers explain that, their background and their experience. We basically relied on that”.

“Barry” specifically commented on the testimony of the medical examiner:

“I remember specifically there was one guy, and I believe he was a doctor from the Maine State Crime Lab. The wounds that were inflicted to the victim, weren't self-inflicted..., I guess knowing he's a doctor, he had ... He gave his qualifications. He'd been working for the Maine State Crime Lab for a long time. I don't remember exact years, but I think knowing he obviously has hundreds of hours, I think that those are all important.”*

*The medical examiner works for the Maine Attorney General’s Office, not the Crime Laboratory.

Confidence and Demeanor

The most common reasons jurors gave to describe how they evaluated an expert witness' credibility was based on the expert's demeanor and their confidence on the witness stand. "Gillian" described how she based credibility on:

"their knowledge of fields and their confidence on the stand".

"Gary" described the credibility in the same trial as:

"demeanor, I guess, to a degree. Good old fashioned judge of character. Sometimes the defense tries to get under their (expert witnesses) skin, so to speak, and you can see how people react, and you can see a seasoned veteran sometimes by that. I saw that first hand at the ...case."

"Alana" commented on both prosecution and defense experts:

"You could tell the ones that were trying to just spin a line and the ones that were the honest ones and that were real sincere about their job and or the ones that were trying to avoid [sic] the answering (the question)."

"Justin" described how confidence and credibility were connected to how well an expert could answer difficult questions;

"It does influence your perception of the person, how they come across, if they're back tracking or they're tripped up by the lawyer and try to answer it, instead of just saying I'm not sure about this or if it sounds like a contrived answer then that kind of sways my thinking about what the person (expert) is saying."

Experts being put forth by the Government

Some jurors appeared to believe that credibility automatically applied to any expert accepted by the judge. “Grace” believed the expert witnesses were formally licensed as forensic scientists and as expert witnesses. At this time forensic scientists in the State of Maine are not licensed and the decision to allow an individual to testify as an expert rests with the judge alone.

“They (expert witnesses) were licensed by the State of Maine to do the work that they did.”

It is to be expected that jurors who are unfamiliar with the role of forensics scientists and the responsibility of the judge as the gatekeeper might place undue weight on the credibility of an expert just because they work for the government. “Justin” explained it as:

“There is a whole level of inherent trust that you tend to apply to someone who comes forward that is brought to the case from the government.”

“Matthew” expressed how he determined credibility:

“I think that if you are employed by the government of Maine, I'd like to think that they're only going to hire people that know what they're talking about.”

For many professions in Maine and across the United States, licenses and certifications are necessary to perform business. Examples include hairdressers, barbers, tax accountants, nurses and doctors. This is not the case currently for forensics scientists. “Larry”, and possibly others, inferred that since licenses required in other industries, forensic scientists were also licensed.

“I would have to first feel comfortable that the party introducing them to me is credible and then that I have trust in whoever is coming. I work in a field, here in

my job where an engineer puts their stamp on something, they're speaking on behalf of an industry standard or whatever. They're actually liable personally for what they're saying. I would hope that if we had an expert witness talking about whatever, I heard all kinds of them. I guess, myself knowing industry standards, I would make the, and I hate to use the word assumption but I will, assumption that they're speaking on behalf of their field of expertise and I would like to believe that they are offering credible information rather than tainted information. The experts were acting as representatives of the state of Maine rather than some private hire for the gun industry, or something. My opinion was that they had to be credible to serve doing the functions they were for the state."

How the Expert Witness Explained the Evidence

Many of the jurors explained that credibility was tied to how the expert witness explained the evidence they were called to testify about. Expert witnesses know it is important to make sure the scientific evidence is accessible and understandable to the lay juror. This brings to light the fact that the ability of the expert to explain the scientific evidence is tied to credibility in the juror's mind. "Martin" explained credibility this way:

"as they have a conversation about their area of expertise, how did they explain it? Were they explaining in a way that they had a command of the information and yet they could explain it to lay people and the jury in a simple way?"

"Gregory" explained credibility in almost the same manner:

"I think their ability to explain ... On the scientific side of it, their ability to explain what they're talking about in layman's terms."

The jurors expect the expert witness to present in a clear manner and also expect the testimony to be engaging. “Harold” stated that credibility was based on:

“how they come across, their personality. Some people can be experts and be very rigid and stuffy and whatever and other people have come across quite naturally and I think that's a part of (credibility)”.

“Matthew” described how the way a bloodstain pattern expert explained the science behind bloodstain pattern analysis lent to his credibility:

“But those that specialize in blood spatter, so they can tell which way a blade was being thrown, forward or backward or what, and I guess just, in general, science has proven that to be true, the way that they present it to you.”

Style of Testimony and Definitiveness of Conclusions

During the interview jurors stated that they appreciated when the expert witnesses used visual aids (forensic pathologists, fingerprint examiners, physical match examiners and tool mark examiners). The forensic pathologists used traditional poster presentations. These posters explained where particular wounds were documented on the victim’s body. The tool mark, fingerprint and physical matching experts used PowerPoint type displays to help explain their conclusions.

“Harold” commented that he based the credibility of a tool mark examiner on her style of testimony where she demonstrated a comparison between a wrench and a skull fracture:

“She was able to show that she believed that one fracture was caused by the front of the wrench, one was caused by the back of the wrench and one was caused by the side of the wrench where you could actually see the threads from the adjustable screw. I was totally impressed with that woman, but she did say...she

couldn't say beyond a shadow of a doubt that that was what happened. She just blew me away and then I just believed the woman."

"Martin" also described that a visual display of the evidence lent to the credibility of the testimony:

"the visualality (sp) of that evidence. What I mean by that is the forensic team explained and did a 360 degree visual pictures of everything".

"Damon" described the presentation of the evidence at the trial as being very important to him in determining the credibility of the testimony of the medical examiner who testified about a gunshot wound in the victim's body:

"a picture of a neck and then (he) showed that going through it at this angle and then draw it in one more view, of the front view, then you could get the idea where that was going through."

"Justin" explained that the credibility of a crime scene examiner depended on how he demonstrated the evidence found at the entry point (on a door) in court:

"Justin": *This is a simple example, but they showed the backdoor before they took it off and they actually had brought the door to the evidence room. You could see that some markings were the same and it wasn't just a person saying that. The door was also a picture on the home that kind of backed it up.*

Researcher: *They brought the door to the court?*

"Justin": *Yes, they did, yeah. They showed us the knife marks and stuff.*

Researcher: *Okay. My next question is ... Sorry, go ahead.*

"Justin": *For me it takes more than just someone's word to incriminate somebody to make it a fact.*

In reference to a homicide scene where bloodstains were found in multiple rooms of the home and the defense put forward a theory that the defendant was acting in self-defense "Matthew" described how he based the credibility of a blood spatter expert on their ability to

explain the blood stain patterns found at the crime scene through verbal testimony and the use of crime scene phonographs.

Researcher: Okay. Perfect. What makes you think an expert witness is credible? If you think back to the trial, when you saw the scientific witnesses, how did you know if they were credible or not?

“Matthew”: Well, that's a good question. I guess I can use this one as an example. They had blood spatter ... What's the term ... But those that specialize in blood spatter, so they can tell which way a blade (of a knife) was being thrown, forward or backward or what, and I guess just, in general, science has proven that to be true, the way that they present it to you.

When forensic scientist's testified about the evidence it was clear that some expert witnesses developed more of a rapport with the jury than other witnesses. When the expert witness played more of an educator's role and took the time to teach the jurors a little about the science and how they came to their conclusions the jurors appeared to be more engaged. Jurors nodded their heads, made a lot of eye contact with the expert and looked at their fingers during the testimony of the fingerprint experts. “Amy” described how she determined if an expert witness was credible:

“I think being confidence, being able to answer questions in detail, and being able to bring it down to a level for other people to understand it. I think almost like teaching, people who have a good knowledge base of the subject matter are able to look at their audience and teach the subject. Some people who just spout off key phrases without being able to explain or having any knowledge about detail I think tend to not be as credible as other people who have more subject matter detail”

Jurors mentioned that they did not understand DNA evidence and that this lack of understanding may have influenced their overall rating of the witness's credibility. The footwear and tire mark evidence experts testified to class characteristics associations and not individualizations or ‘matches’. They testified that the crime scene impression(s) and

known shoes/tires had the same pattern but could not be more specific in their conclusions.

“Charlotte” stated:

“The tire tracks, I think that it is more difficult, it’s not always clear cut, if it actually was the specific tire”.

Figure 6 illustrates the spread of jurors’ rating of expert witness credibility across the disciplines. Apart from the fingerprint examiners, all of the other expert witnesses were rated very credible or credible by the jurors.

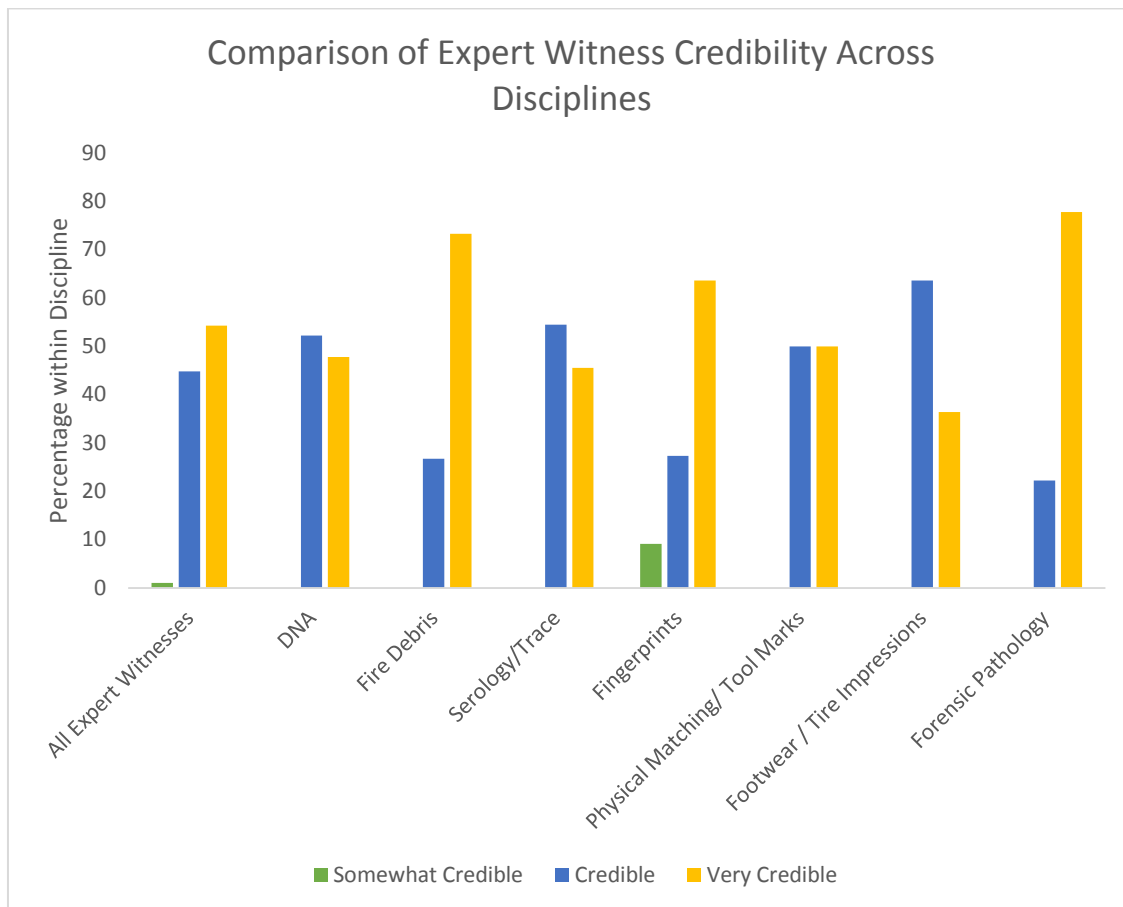


Figure 6: Jurors’ Interpretation of Expert Witness Credibility

Conclusions and Discussion

The jurors in this study defined expert witnesses as ‘knowledgeable’ and as people who had received “specialized training”. When asked to rank qualifications of an expert witness more jurors ranked experience in the specialized area as most important than those who ranked university education most important. This is consistent with other studies which found that jurors place a lot of weight on the expert’s experience (Koehler et al., 2016) and that university education is slightly less important to them (Schutz, 1997, Cooper et al., 1996). Many of the jurors stated that they believed both were very important.

On the job training and certifications were slightly less important to the jurors and of least importance were continuing education such as attending workshops and conferences or whether or not the laboratory the expert worked for was accredited. This study indicates that jurors place strong value on the qualifications of the forensic scientist and this information may be important for crime laboratory management and those who hire and retain scientific experts. If jurors place a lot of weight on the experience of the expert then forensic scientists with only a few years’ experience will have to highlight their other qualifications (e.g. on the job training, certifications and university education) to the jurors when qualifying as an expert.

Currently, the United States Federal government is moving forensic science towards universal standards in processing methodologies, conclusions and ultimately to national credentials for forensic scientists. These are important steps in promoting quality in forensics science, but jurors are evaluating the expert witness on their experience and expertise. In the future laboratory accreditation may be necessary to apply for and secure federal funding. While these policies and procedural changes are a step in the right direction for forensic science it is very important to keep the jury in mind. This research suggests that expert witnesses should make jurors more aware of the benefits of laboratory accreditation and continuing education of expert witnesses.

The credibility of an expert witness can be defined as how persuasive that person is when they give testimony (Ivkovic, 2003, Pope et al., 2006). Pope suggests that credibility is related to the expert’s “authoritativeness, character, competence, attractiveness and expertness” (Pope et al., 2006). Understanding how jurors interpret witness credibility is important as it has been

shown to influence perceptions of evidence reliability and verdicts (Cramer et al., 2009, Ivkovic, 2003). This research supports the previous studies which identified likeability, believability, trustworthiness and intelligence as being the main factors which influence jurors' perceptions of forensic science expert witnesses (Brodsky et al., 2010). In this study the jurors described that the expert's confidence and demeanor when testifying were the most important factors in determining their credibility as a witness. Jurors also used the number of years' experience the expert witness had gained, as well as their qualifications, to establish credibility. Sometimes prosecution or defense lawyers will offer to stipulate to the witness's expertise to save time during the trial or to minimize their ability to gain credibility with the jury. This research indicates that the process of qualifying an expert before testimony about the evidence begins is a necessary and very important for the expert and the jury.

Of some concern to the justice system may be the responses from jurors who based the expert witness's credibility on the fact that they were governmental employees or that they were presented by a prosecution attorney. Defense attorneys need to be aware that jurors may place additional confidence in experts employed by the government and may choose to highlight that history had shown that governmental laboratories do make mistakes (Garrett and Neufeld, 2009).

This study supports previous research which indicates that experts appear more credible to the jury when they take the time to teach the jury about how they came to their conclusions and supported their testimony through the use of demonstrative aids (Rosenthal, 1983, Gutheil, 2000, Blau et al., 2017). If the evidence or the expert's conclusions can be demonstrated using a visual aid this will likely aid the jury's understanding and in turn increase the perception of the expert's credibility.

Limitations:

The limitations of these findings are that they are based on a small sample size. 144 jurors were contacted and 29 jurors filled out the survey and of these, 20 participated in the phone interviews giving a response rate of 20% and 14% respectively. The response rate per trial ranged from 1 juror to 5 jurors and for one trial there were no responses. The sample was made up of jurors who self-selected to participate and as such was not a randomized sample.

The circumstances of the homicides, how the trials progressed, how the expert witnesses testified and how the jurors viewed the testimony are unique and independent events. In order to determine if patterns existed in the data, juror responses to expert evidence over all the trials were combined.

Every effort was taken to minimize researcher bias but it is a concern in all qualitative studies.

Lastly, this research was carried out in Maine and only homicide trials were part of the study. This narrow scope may influence how these findings can be applied to other jurisdictions and crime types.

Research involving post trial surveying and interviews of jurors will always have limitations. It is very difficult to get the perfect sample that can represent the greater population. These limiting factors should be considered when applying these results to other populations and circumstances.

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Appendix A

Please answer the following questions about yourself and the trial where you were a juror or alternate.

1. What is your gender?

- ☐ Male
- ☐ Female

2. How old are you?

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ 65+

3. What is the highest level of education you have completed?

- ☐ Less than high school
- ☐ High school/ GED
- ☐ Some college
- ☐ Two year college degree (Associate)
- ☐ Four year college (BS or BA)
- ☐ Master's degree
- ☐ Doctoral degree

4. List in order of importance (6= least importance, 1= most importance) the most important qualifications of an expert witnesses

<input type="checkbox"/>	University Education
<input type="checkbox"/>	On the job training
<input type="checkbox"/>	Certifications
<input type="checkbox"/>	Years of experience
<input type="checkbox"/>	Working in an accredited laboratory
<input type="checkbox"/>	External training, such as conferences, workshops

5. With regard to (insert Expert witness name and brief description to the content of testimony) how credible (believable) was his/her testimony?

- ☐ Not credible
- ☐ Somewhat credible
- ☐ Credible
- ☐ Very credible

6. How effectively did the (forensic scientist e.g. firearms examiner) explain to you how he/ she came to his /her conclusions?

- ☐ Poor Job
- ☐ Fair Job
- ☐ Good Job
- ☐ Great Job

7. Did the chart/ demonstration/ media presentation help you understand the subject matter (e.g. bullet trajectory?)

- ☐ Not at all
- ☐ To some extent
- ☐ To large extent

Appendix B

Phone interview questions

1. I would like to go back to one of the questions on the paper survey, the question stated list in order of importance the qualifications of an expert witness, University education, on the job training, certifications, years of experience, working in an accredited lab and external training such as conferences/workshops. Ask juror to confirm their order that they put on the paper survey

2. Ask them to define what an expert witness is then ask: What makes you think an expert witness is credible?
3. Which is more important in an expert witness qualifications or experience and why?
4. Did you feel that you didn't understand any of the scientific evidence and if so what would have helped?

Original Research Article

Title:

Jurors' perceptions of Forensic Science Expert Witnesses: Experience, Qualifications, Testimony Style and Credibility

Authors:

Abstract

The judicial system calls upon expert witnesses to testify in court when complex or specialized knowledge, beyond that of the lay person, is needed to interpret the evidence. Previous research had indicated that particular traits of the expert witness demonstrated their credibility to the jury, however most of this research was undertaken using mock jurors. In contrast, this study investigated the perceptions of real jurors. In particular, the research work focused on the juror's perception of the forensic scientists' expertise and credibility during testimony in homicide cases. Data was gathered from jurors after they had completed jury duty in one of nine homicide trials using both questionnaire (n=29) and direct one to one interviews (n=22). The jurors defined what they thought an expert witness was and what attributes were important in a forensic scientist. Jurors suggested that the expert witness' education and years of experience were more favored over specific certification or laboratory accreditation. The jurors' perceptions of the credibility of the expert was based upon the academic qualifications of the expert, the confidence they portrayed in answering the questions put to them, their demeanor and their status of being a prosecution witness (State of Maine government employee).

The role of the use of narrative in evidence was explored in particular through the use of demonstrative aids to explain the scientific evidence presented. Jurors described a deeper understanding as a result of such testimony and the narrative testimony of the witness was reported to be a key factor in the juror's acceptance that the witness was credible.

Key Words

Forensic Science, Expert Witness Credibility, Education, Jury Decision Making, Criminal Trials, Expert Testimony

Introduction

How jurors perceive expert witnesses who testify is an area of research interest to judicial stakeholders. In an adversarial system, such as that in the United States, a persuasive witness could change the course of the trial and potentially have a significant influence on jury decision making. Understanding what factors and attributes in the expert witness translate to credibility in the juror's mind is therefore valuable information for judges, attorneys and forensic scientists.

Early research indicated that jurors perceive expert witnesses' credibility based on the appearance of the witness. A disadvantage of the current body of research however is that most has been based primarily on mock juries, and in a limited capacity on real juries. Previous research has examined the attributes of expert witnesses who testified as expert physicians, accountants, biochemists, engineers (Champagne et al., 1991), or actors trained as experts on recidivism (how likely a defendant will commit the same crime again) (Brodsky, Neal, Cramer, & Ziemke, 2009). In other work, psychology experts simulating testimony in capital sentencing cases (Brodsky et al., 2010) have asked mock jurors questions about hypothetical expert witnesses (Saks & Wissler, 1984).

The main findings of much of previous research on witness credibility has been that the witness's attire, whether they wore glasses, carried a briefcase or for women if they wore their hair up or down influenced how jurors judged the knowledgeability of the expert (Tanton, 1979). Brodsky *et.al* reviewed the literature and found that juror's descriptions of credibility of expert witnesses could be condensed into four main categories; likability, believability, trustworthiness and intelligence (Brodsky, Griffin, & Cramer, 2010) where likability was found to be the most significant factor which influenced the juror's perception of trustworthiness of the expert witness (Cramer, Brodsky, & DeCoster, 2009). It has also been shown that jurors were more likely to find expert witnesses more credible when they explained complex testimony clearly (Champagne, Shuman, & Whitaker, 1991; Hastie, Penrod, & Pennington, 1983) and that when

an expert used demonstrative aids such as charts, then the perception of the expert witnesses' credibility increased (Gutheil, 2000). When jurors did not understand the expert's testimony, they have been shown to take heuristics, or mental shortcuts relying on the appearance and communication skills of the expert as a measure of their credibility (Rosenthal, 1983).

It is highly likely that the credibility of the expert witness is based on multiple factors rather than one single factor. This research attempted to explore this area in some depth and with real jurors rather than under conditions of simulation.

Methodology

The aim of this research was to gain an understanding of the factors that influence jurors' views of the credibility of forensic science expert witnesses. A parallel convergent exploratory mixed methods design was used to approach this research question (Figure 1).

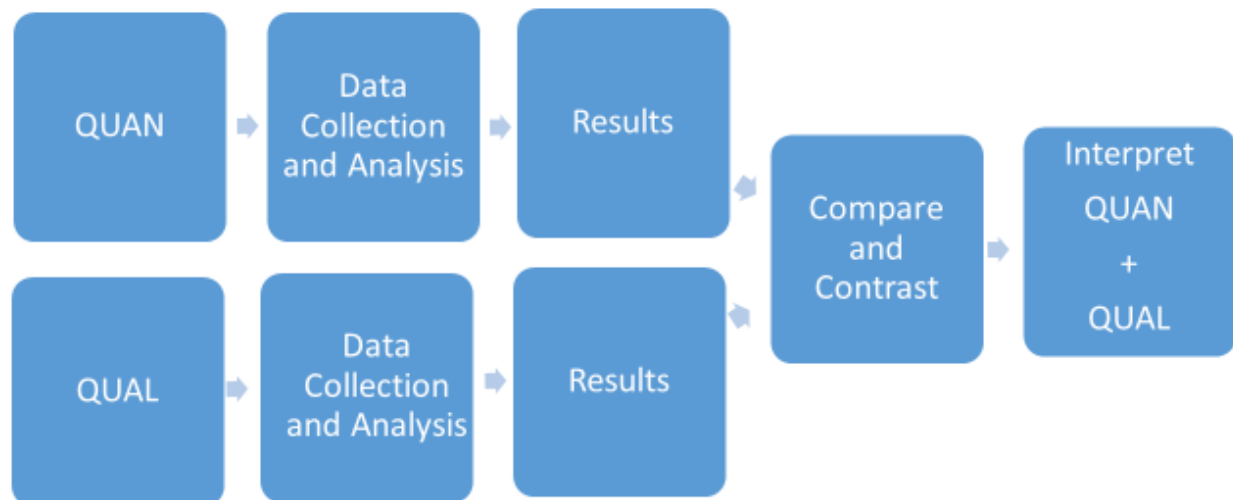


Figure 1: Parallel Convergent Mixed Method Approach

The data collection was carried out over a 24 month period using both survey and structured interview questions. Judicial approval was obtained in order that jurors could

be approached. The researcher attended the trials and watched the portions where forensic science testimony was given by experts called by the prosecution. Following the trial, a survey was posted to all jurors and alternate jurors. Jurors (N=29) returned the survey and a subset of these jurors (N=22) participated in structured phone interviews. The data were then organized and analyzed. To ensure juror confidentiality and anonymity, jurors were given pseudonyms. Pseudonyms of individuals who were jurors in the same trial were given names that began with the same letter.

Results

During the study, a set of questions was asked which specifically related to the jurors' perception of the forensic science witnesses. These included both survey (Appendix A) and interview questions (Appendix B). The purpose was to elucidate responses which would provide information relating to how the jurors' valued both the expertise and experience of the expert and to seek information on factors which might influence their perceptions of the expert's credibility.

Jurors' Definition of an Expert Witness

The jurors defined an expert witness in multiple ways but many definitions contained common descriptors such as '*knowledgeable*' and '*specialized*' and as someone who had '*received training*'. "Justin" described a forensic science witness as:

"Somebody ...who has training. To me it's important to have a college background, scientific background. If you're going to be analyzing data, you need to understand statistics and also processes and knowing what procedures are and following them. Just because somebody takes a six weeks course doesn't really, to me, qualify them as an expert."

In "Harold's" words an expert is:

“somebody by virtue of their training and experience that has a high level of expertise in a particular area.”

“Martin” had a similar description:

“I would classify an expert witness as an individual with both experience and education specific to a field to offer expert testimony.”

A few jurors indicated that a certain amount of experience was necessary to truly be considered an expert witness. “Alana” stated:

“I truly believe you have to be at least five years on the job”

and “Gail” also described experience as important:

“somebody with a lot of experience, has been working in it for quite a while”.

For some jurors, credentials and certifications were an important part of the definition of an expert witness. “Gillian” expected forensic science experts to have:

“licenses or certifications pertaining to that field”

and “Matthew” said experts should have:

“credentials or certificates of competency”.

“Barry” described an expert in terms of a Certified Public Accountant (CPA) in a hypothetical case involving fraud:

“An expert witness in my mind, I think it's like a professional in that if there was, tax evasion or ...if it was something finance related, if you had a CPA, I feel (would be) an expert in that field”.

Qualifications, Training and Certifications of an Expert Witness

One question on the survey question (Appendix A, question 4) asked jurors (n=25) to rate, in order of importance the qualifications and background criteria for an expert witness. The results combined across all 25 jurors are presented in Table 1 and Figure 3.

Table 1: Importance of qualifications in an expert witness

	Rank					
	Most important			Least important		
	1	2	3	4	5	6
University Education	7	7	5	1	1	4
On the Job Training	0	11	4	4	3	3
Certifications	2	7	5	6	3	2
Years of Experience	15	0	5	4	1	0
External training	0	0	2	6	6	11
Working in an accredited lab	1	0	4	4	11	5

Rank: 1= Most Important, 6= least important (red = below 25%; orange= >28-59%; green=>60%)

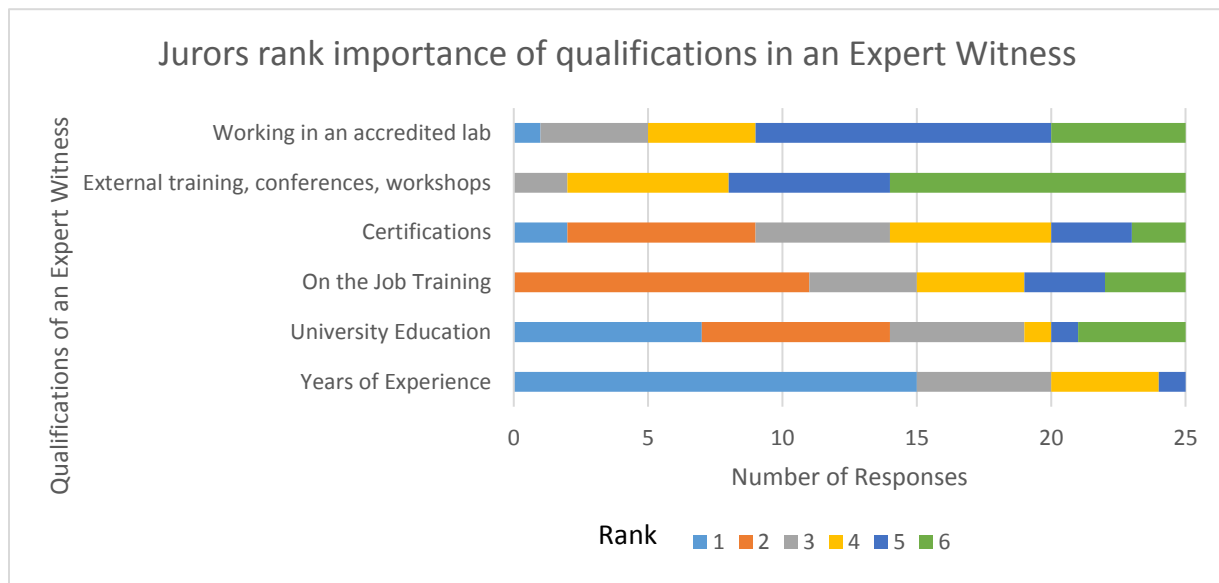


Figure 2: Jurors' interpretation of the importance of qualifications in an expert witness
(Rank: 1= Most Important, 6= least important)

There was no one qualification that all jurors found important. Years of experience was ranked in the top 3 by 80% of the jurors, university education was ranked in the top 3 by 76% of the jurors and on the job training was ranked in the top 3 by 60% of the jurors. Less important to the jurors was whether the expert worked in an accredited lab or the expert's external training. 80% of the jurors ranked "working in an accredited lab" in the lower three positions and 92% of jurors ranked external training in the lower 3 positions. (Table 2).

Table 2: Importance of qualifications in an expert witness

	Rank in importance		
	Most	Least	
	1&2	3&4	5&6
University Education	14 (56%)	6 (24%)	5 (20%)

On the Job Training	11 (44%)	8 (32%)	6 (24%)
Certifications	9 (36%)	11 (44%)	5 (20%)
Years of Experience	15 (60%)	9 (36%)	1 (4%)
Working in an accredited lab	1(4%)	8(32%)	16(64%)
External training	0	8 (32%)	17 (68%)

(red = below 25%; orange= >30-59%; green =>60%)

The data may have been influenced by the jurors' perceptions of higher education, where over 80% ranked experience and education high irrespective of whether they themselves had attained education beyond the high school level.

A Pearson correlation coefficient was calculated for university education and years of experience. There is a statistically significant inverse correlation between a juror's ranking of university education and their ranking of years of experience ($r = -.547$, $N=25$, $P=.01$). Jurors who tended to rank university education high also tended to rank years of experience low, and vice versa. This data is illustrated in Table 3 and Figure.

Table 3: Correlations of the ranking by Jurors of an expert witnesses qualifications

	University Education	OJT	Certifications	Experience	Working in an accredited lab	External Training: Conferences/ workshops
University Education	1	-.299	-.051	-.522**	-.196	.163
OJT	-.299	1	-.511**	-.060	-.127	-.155
Certifications	-.051	-.511*	1	-.189	-.166	-.078
Experience	-.552**	-.060	-.189	1	-.231	.300

Working in an accredited lab	-.196	-.127	-.166	-.231	1	-.237
External training: conferences/workshops	.163	-.155	-.078	-.300	-.237	1

**Highlighted areas indicate correlations which are significant at the 0.01 level (2-tailed)

The same was true for the correlation between on the job training and certifications ($r = -.511$, $N = 25$, $P = 0.01$). Jurors who ranked on the job training high tended to rank certifications low. This appears to indicate that jurors either put weight on formal education of the expert witnesses, such as certifications and university education and placed value on the job training and years of experience less, or vice versa. This may be due to the juror's own experience and whether they had a formal education or learned their skills on the job. The small sample size is a limitation that needs to be considered with these observations.

		Years of Experience		
		Rank 1-3 (high)		Rank 4-6 (low)
University Education	Rank 4-6 (low)	<div>25-34 BS</div>	<div>55-64 HS</div>	<div>35-44 AS</div>
		<div>35-44 AS</div>	<div>45-54 BS</div>	<div>25-34 MS</div>

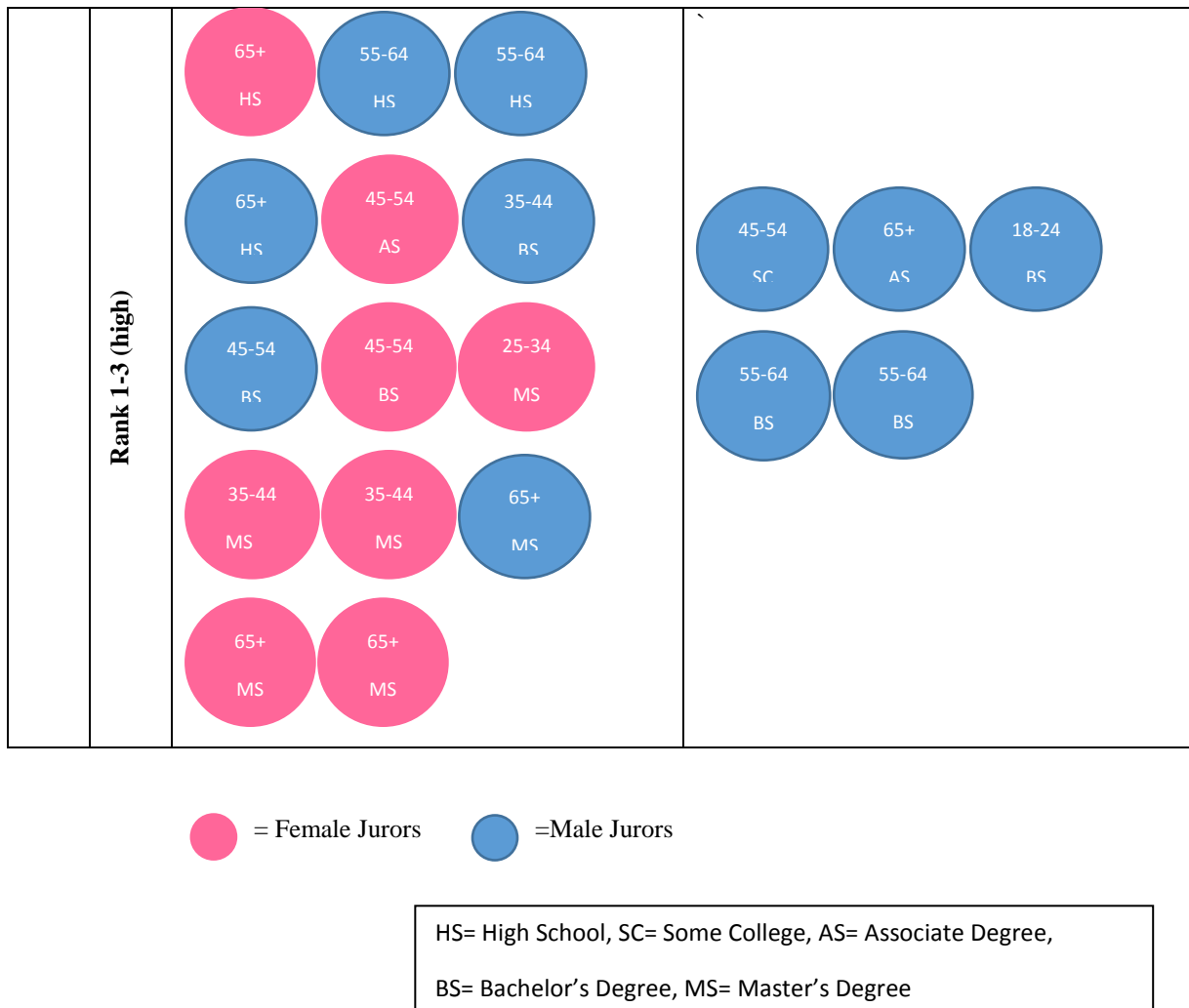


Figure 3: Comparison of gender, age and education level of jurors within the ranked categories of years of experience and university education.

In response to the interview question “Which is more important in an expert witness, qualifications, such as education or certifications or years of experience?” (Appendix B, question 3) the majority of jurors, 63%, stated that years of experience was more important in an expert witness than qualifications (Figure 5) supporting the data derived from the paper survey.



Figure 4: Jurors’ evaluation of the importance of formal qualifications vs. years of experience

Jurors thought experience was the most important factor in an expert witness and explained that although education and certifications are important for a forensic scientist, they felt that it was the application of this knowledge (through job experience) that led to expertise. “Amy” stated:

“I think there are some people who can get many certifications and take many courses and classes, but they can't actually apply it and have never applied it. I think there are people who have developed significant experience in the subject matter from just seeing, doing, being around it, being around other people”.

Jurors described the value of experience in terms of the variety of evidence types a forensic scientist might be called on to analyze. “Amy” said that a person with experience would be better than a person with only qualifications when the evidence was complex or outside of what might be expected:

“(forensic scientists) having a sense of what the norm would be and things that would not necessarily be the norm.”

“Dana” described the benefit of experience to the forensic scientist as:

“Highly qualified people do not necessarily have the vast experience to know what is average or extraordinary or usual”.

“Dorothy” felt experience allowed the scientist a range of approaches when examining evidence:

“because every case is a little bit different, and I think that there's more flexibility in experience. (Evidence is) not as standard as stuff you get from the textbook”.

Some of the jurors related the value of experience back to their own professions and job experience. There was an understanding among jurors that forensic science as a profession cannot be learned solely from books. “Lloyd” said;

“I'm an accountant. When I started accounting, even though I had learned all this stuff, actually seeing it in practice the first time ...things are a little different than what you see in the book. You have to be able to recognize that. I would say that experience is probably, with the proper qualifications or the training, experience would be more important than the qualifications”.

“Larry” explained the value of experience by relating it to a life event:

“I would say years of experience, and here's a good example. My wife was seeing a medical specialist and saw him for several years, and he had qualifications. He had certificates and he had fancy diplomas, and he lost his medical license because he didn't know what ... he was doing. I would much rather, someone in a very serious professional field, I would much rather have someone that had a lot of experience and was competent.”

The challenge for new forensic scientists in qualifying as an expert in court will be to describe their qualifications and also how they have learned the discipline through supervised casework or other internal training. “Larry” explained:

“For example, if someone were soon out of college, I don't know that they're going to be an expert witness but they do have the necessary education to get them there. Some of those things go hand in hand. Experience is very important but their upbringing or background enters into it as well. I would think that a journeyman so to speak would be working with an expert witness and would become an expert witness over time based on both education and then experience in the career.”

A few jurors described the connection between experience and qualifications. To gain experience you need qualifications and to gain credentials you need experience. Certification in many of the different forensic science disciplines requires the scientist to have a certain minimum number of years of experience, so it is true that credentials such as certifications require experience as well. “Ann” said:

“it's hard for me to almost differentiate them because my assumption would be if they're credentialed in anyway, that that process means that they do have experience. I guess I would say credentials, assuming that that comes along with some kind of procedure, or protocol, before they are credentialed that would involve experience.”

“Gillian” also felt that experience and qualifications went hand-in-hand:

“I think it varies because, well, personally I say both in order gain the qualifications you have to have the experience”.

For the most part the jurors valued both experience and the formal qualifications of the expert witnesses. “Grace” described why she thought both education and experience were important in an expert:

“I think both are important but a person wouldn't be reliable if they didn't have the proper qualifications and I think that's just the standardized way of demonstrating someone's expertise in the field is usually if they have a certain credential there. They're passing the test but they're also certified at that level by having years of experience. Someone doesn't just pass the test and become a Medical Examiner. They're supervised and they're given feedback. To me, the qualification supersedes experience because it includes experience.”

When speaking of the importance of qualifications jurors focused on the value of foundational knowledge needed by a forensic scientist that the jurors described should be based on education and other credentials. “Justin” described expertise in terms of his own experience as an engineer:

“I guess for me qualifications. I'm an engineer and the only way that I could get my professional engineering license was by having a certain number of years of experience. Then I'd have to have other professional engineers sign off that they've observed me and witnessed my performance. I'd have to have a certain amount of education in order to pass. I think qualifications is higher than experience”.

Judging the Credibility of the Forensic Science Expert Witness

The credibility of an expert witness can be defined as how persuasive that person is when they give testimony (Ivkovic, 2003, Pope et al., 2006). Pope suggests that credibility is related to the expert's “authoritativeness, character, competence,

attractiveness and expertness” (Pope et al., 2006). Understanding how jurors interpret witness credibility is important as it has been shown to influence perceptions of evidence reliability and verdicts (Cramer et al., 2009, Ivkovic, 2003)

Jurors were asked in the survey to rate the credibility, in their view, of the expert witnesses that they watched during the trial. The jurors who participated in the follow-up phone interviews were asked to describe how they determined if an expert witness was credible. Jurors rated all the expert witnesses they watched as being credible. Figure x illustrates the breakdown of the evaluation of credibility across all of the expert witnesses. 99% of the jurors felt that the expert witnesses were either very credible (54%) or Credible (45%).

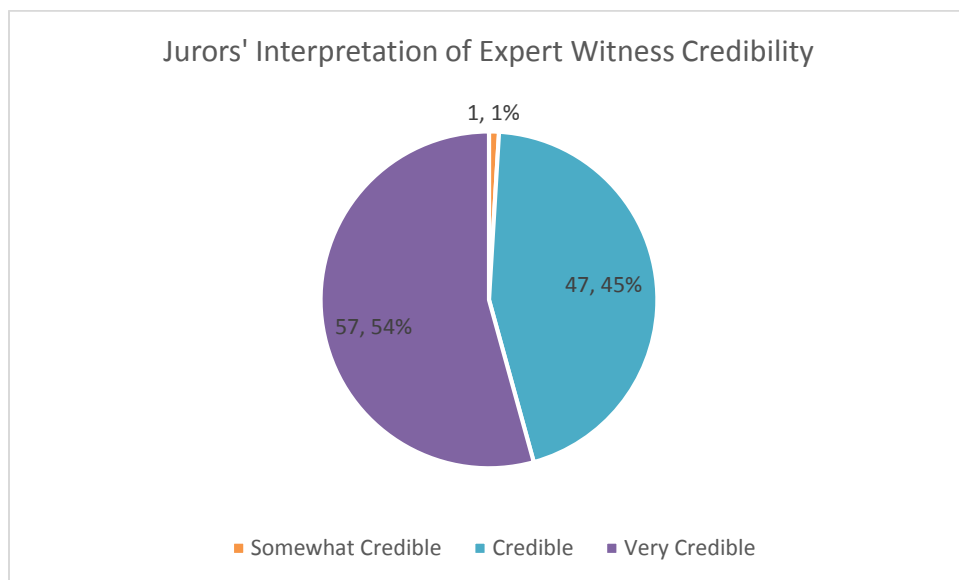


Figure : How jurors rated credibility of all expert witnesses who testified at their trial

Qualifications

Jurors described their view of the expert witnesses' credibility based on the experts' qualifications. Each time a forensic science expert witness testifies in the State of Maine

they answer questions asked by the attorney who called them. This gives the Court an opportunity to decide if the individual is an expert for the purposes of the trial. This process gave credibility to the expert witnesses. “Grace” explained:

“I believe that they were credible when they went through and introduced their background. They wouldn't just come up and start answering questions. They would begin by ... Well, actually it was from a question. The first question would be describing your background or qualifications or credentials. When they described that aspect, that's what sold me in trusting what they had to say.”

“Lloyd” stated how he determined credibility of an expert witness as:

“the lawyers explain that, their background and their experience. We basically relied on that”.

“Barry” specifically commented on the testimony of the medical examiner:

“I remember specifically there was one guy, and I believe he was a doctor from the Maine State Crime Lab. The wounds that were inflicted to the victim, weren't self-inflicted..., I guess knowing he's a doctor, he had ... He gave his qualifications. He'd been working for the Maine State Crime Lab for a long time. I don't remember exact years, but I think knowing he obviously has hundreds of hours, I think that those are all important.”*

*The medical examiner works for the Maine Attorney General's Office, not the Crime Laboratory.

Confidence and Demeanor

The most common reasons jurors gave to describe how they evaluated an expert witness' credibility was based on the expert's demeanor and their confidence on the witness stand. "Gillian" described how she based credibility on:

"their knowledge of fields and their confidence on the stand".

"Gary" described the credibility in the same trial as:

"demeanor, I guess, to a degree. Good old fashioned judge of character. Sometimes the defense tries to get under their (expert witnesses) skin, so to speak, and you can see how people react, and you can see a seasoned veteran sometimes by that. I saw that first hand at the ...case."

"Alana" commented on both prosecution and defense experts:

"You could tell the ones that were trying to just spin a line and the ones that were the honest ones and that were real sincere about their job and or the ones that were trying to avoid [sic] the answering (the question)."

"Justin" described how confidence and credibility were connected to how well an expert could answer difficult questions;

"It does influence your perception of the person, how they come across, if they're back tracking or they're tripped up by the lawyer and try to answer it, instead of just saying I'm not sure about this or if it sounds like a contrived answer then that kind of sways my thinking about what the person (expert) is saying."

Experts being put forth by the Government

Of some concern to the justice system may be the responses from jurors who based the expert witness credibility on the fact that they were state employees or being presented by a prosecution attorney. These jurors appeared to believe that credibility automatically applied to any expert accepted by the judge. “Grace” believed the expert witnesses were formally licensed as forensic scientists and as expert witnesses. At this time forensic scientists in the State of Maine are not licensed and the decision to allow an individual to testify as an expert rests with the judge alone.

“They (expert witnesses) were licensed by the State of Maine to do the work that they did.”

It is to be expected that jurors who are unfamiliar with the role of forensics scientists and the responsibility of the judge as the gatekeeper might place undue weight on the credibility of an expert just because they work for the government. “Justin” explained it as:

“There is a whole level of inherent trust that you tend to apply to someone who comes forward that is brought to the case from the government.”

“Matthew” expressed how he determined credibility:

“I think that if you are employed by the government of Maine, I'd like to think that they're only going to hire people that know what they're talking about.”

For many professions in Maine and across the United States licenses and certifications are necessary to perform business. Examples include hairdressers, barbers, tax accountants, nurses and doctors. This is not the case currently for forensics scientists.

“Larry”, and possibly others, inferred that since licenses required in other industries, forensic scientists were also licensed.

“I would have to first feel comfortable that the party introducing them to me is credible and then that I have trust in whoever is coming. I work in a field, here in my job where an engineer puts their stamp on something, they're speaking on behalf of an industry standard or whatever. They're actually liable personally for what they're saying. I would hope that if we had an expert witness talking about whatever, I heard all kinds of them. I guess, myself knowing industry standards, I would make the, and I hate to use the word assumption but I will, assumption that they're speaking on behalf of their field of expertise and I would like to believe that they are offering credible information rather than tainted information. The experts were acting as representatives of the state of Maine rather than some private hire for the gun industry, or something. My opinion was that they had to be credible to serve doing the functions they were for the state.”

How the Expert Witness Explained the Evidence

Many of the jurors explained that credibility was tied to how the expert witness explained the evidence they were called to testify about. Expert witnesses know it is important to make sure the scientific evidence is accessible and understandable to the lay juror. This brings to light the fact that the ability of the expert to explain the scientific evidence is tied to credibility in the juror's mind. “Martin” explained credibility this way:

“as they have a conversation about their area of expertise, how did they explain it? Were they explaining in a way that they had a command of the information and yet they could explain it to lay people and the jury in a simple way?”

“Gregory” explained credibility in almost the same manner:

“I think their ability to explain ... On the scientific side of it, their ability to explain what they're talking about in layman's terms.”

The jurors expect the expert witness to present in a clear manner and also expect the testimony to be engaging. “Harold” stated that credibility was based on:

“how they come across, their personality. Some people can be experts and be very rigid and stuffy and whatever and other people have come across quite naturally and I think that's a part of (credibility)”.

“Harold” commented on a tool mark examiner who testified to her comparison between a wrench and a skull fracture:

“I was totally impressed with that woman, but she did say...she couldn't say beyond a shadow of a doubt that that was what happened. She just blew me away and then I just believed the woman.”

“Matthew” described how a bloodstain pattern expert explained the science behind the repeatability of bloodstain patterns and how this explanation lent to the credibility of the expert:

“But those that specialize in blood spatter, so they can tell which way a blade was being thrown, forward or backward or what, and I guess just, in general, science has proven that to be true, the way that they present it to you.”

Style of Testimony and Definitiveness of Conclusions

During the interview jurors stated that they appreciated when the expert witnesses used visual aids (forensic pathologists, fingerprint examiners, physical match examiners and tool mark examiners). The forensic pathologists used traditional poster presentations. These posters explained where particular wounds were documented on the victim's body. The tool mark, fingerprint and physical matching experts used PowerPoint type displays to help explain their conclusions.

When forensic scientist's testified about the evidence it was clear that some expert witnesses developed more of a rapport with the jury than other witnesses. When the expert witness played more of an educator's role and took the time to teach the jurors a little about the science and how they came to their conclusions the jurors appears to be more engaged. Jurors nodded their heads, made a lot of eye contact with the expert and looked at their fingers during the testimony of the fingerprint experts.

Jurors mentioned that they did not understand DNA evidence and that this lack of understanding may have influenced their overall rating of the witness's credibility. The footwear and tire mark evidence experts testified to class characteristics associations and not individualizations or 'matches'. They testified that the crime scene impression(s) and known shoes/tires had the same pattern but could not be more specific in their conclusions. This finding is consistent with previous research which found that experts who drew "firm conclusions" were perceived as more credible (Champagne et al., 1991; Shuman, Whitaker, & Champagne, 1994). The footwear and tire evidence across all 9 homicide cases was the least definitive and this may have influenced the overall juror perspectives of the credibility of these expert witnesses.

"Charlotte" stated:

"The tire tracks, I think that it is more difficult, it's not always clear cut, if it actually was the specific tire".

Figure 13 illustrates the spread of jurors' rating of expert witness credibility across the disciplines. Apart from the fingerprint examiners all of the other expert witnesses were rated very credible or credible by the jurors.

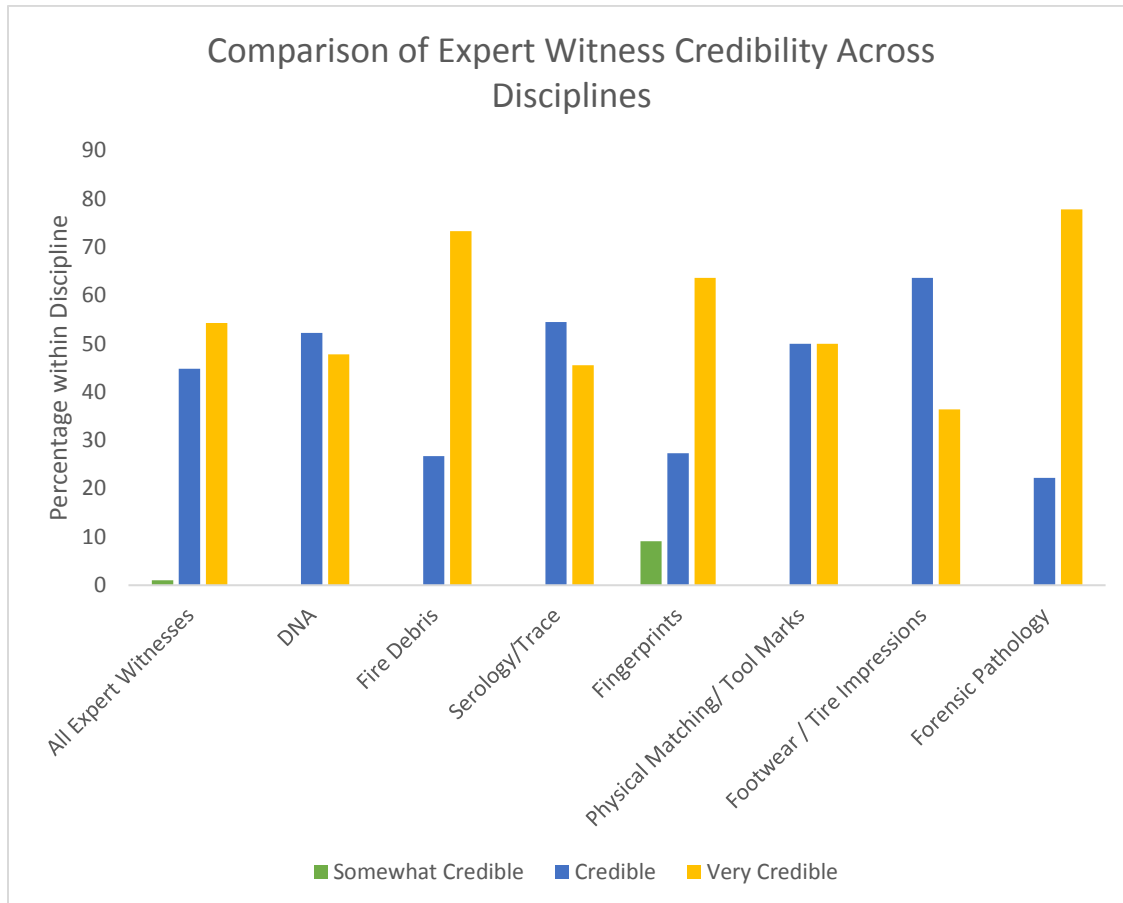


Figure 5: Jurors' Interpretation of Expert Witness Credibility

Summary

Jurors defined expert witnesses as individuals with high levels of training and experience and a few jurors stated that a minimum number of years' experience was needed in order to qualify as an expert. In a few circumstances, jurors stated that an expert was 'licensed' by the jurisdiction they were testifying in and it was apparent that a number of jurors had interpreted the qualification of the expert to mean they had some sort of license to practice as a forensic scientist.

This research supports the previous studies which identified likeability, believability, trustworthiness and intelligence as being the main factors which influence jurors' perceptions of forensic science expert witnesses (Brodsky et al., 2010). This study highlighted that a juror's measure of credibility of the expert witness was based on the expert's demeanor, how they presented their evidence, their confidence and the perception that the State of Maine endorsed them. Jurors were impressed by years of experience and the qualifications of the experts, but also their presentation style. Jurors wanted to grasp and understand the evidence and visual aids helped them in this process. Forensic pathologists, Fire Experts and Fingerprint Examiners were rated the most credible expert witnesses by jurors with Footwear and Tire experts being the least credible.

Conclusions

Expert witness credibility is very important as the expert speaks for the evidence that they are called upon to explain or clarify for the jury. Establishing credibility with the jury needs to come before the expert speaks about the evidence. The jurors in this study used the number of years' experience the expert witness had gained, as well as their qualifications, to establish credibility. This indicates that the process of qualifying an expert before they testify about the evidence is necessary and very important for the expert and the court.

This study shows that jurors place strong value on the knowledge of the forensic scientist. This is important information for crime laboratory management and those who hire and retain scientific experts. Currently, the United States Federal government is moving forensic science towards universal standards in processing methodologies, conclusions and ultimately to national credentials for forensic scientists. These are important steps in promoting quality in forensics science, but jurors are evaluating the expert witness on their experience and expertise.

Laboratory accreditation will in the future be necessary to apply for and secure federal funding. While these policies and procedural changes are a step in the right direction for forensic science it is very important to keep the jury in mind. This research

suggests that should be made more aware of the benefits of laboratory accreditation and continuing education of expert witnesses.

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Appendix A

Please answer the following questions about yourself and the trial where you were a juror or alternate.

1. What is your gender?

- ☐ Male
- ☐ Female

2. How old are you?

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ 65+

3. What is the highest level of education you have completed?

- ☐ Less than high school
- ☐ High school/ GED
- ☐ Some college
- ☐ Two year college degree (Associate)
- ☐ Four year college (BS or BA)
- ☐ Master's degree
- ☐ Doctoral degree

4. List in order of importance (6= least importance, 1= most importance) the most important qualifications of an expert witnesses

<input type="text"/>	University Education
<input type="text"/>	On the job training
<input type="text"/>	Certifications
<input type="text"/>	Years of experience
<input type="text"/>	Working in an accredited laboratory
<input type="text"/>	

External training, such as conferences, workshops

5. With regard to (insert Expert witness name and brief description to the content of testimony) how credible (believable) was his/her testimony?

- Not credible
- Somewhat credible
- Credible
- Very credible

6. How effectively did the (forensic scientist e.g. firearms examiner) explain to you how he/ she came to his /her conclusions?

- Poor Job
- Fair Job
- Good Job
- Great Job

7. Did the chart/ demonstration/ media presentation help you understand the subject matter (e.g. bullet trajectory?)

- Not at all
- To some extent
- To large extent

Appendix B

Phone interview questions

1. I would like to go back to one of the questions on the paper survey, the question stated list in order of importance the qualifications of an expert witness, University education, on the job training, certifications, years of experience, working in an accredited lab and external training such as conferences/workshops. Ask juror to confirm their order that they put on the paper survey
2. Ask them to define what an expert witness is then ask: What makes you think an expert witness is credible?
3. Which is more important in an expert witness qualifications or experience and why?

4. Did you feel that you didn't understand any of the scientific evidence and if so what would have helped?

Original Research Article

Title:

Jurors' perceptions of Forensic Science Expert Witnesses: Experience, Qualifications, Testimony Style and Credibility

Abstract

The judicial system calls upon expert witnesses to testify in court when complex or specialized knowledge, beyond that of the lay person, is needed to interpret the evidence. Previous research has indicated that particular traits of the expert witness can affect their credibility in the eyes of the jury, however most of this research has been undertaken using mock jurors. In contrast, this study investigated the perceptions of real jurors. In particular, the research focused on the juror's perception of the forensic scientists' expertise and credibility during testimony in homicide cases. Data was gathered from jurors after nine homicide trials using both questionnaire (n=29) and direct one to one interviews (n=22). The jurors defined what they thought an expert witness was and what attributes were important in a forensic scientist. Jurors suggested that the expert witness's education and years of experience were more important than certification or laboratory accreditation. The jurors' perceptions of the credibility of the expert was based upon the academic qualifications of the expert, the confidence they portrayed in answering the questions ask of them, their demeanor and their status of being government employee.

The use of narrative language and demonstrative aids by the forensic science expert witness to explain the evidence was explored. Jurors described a deeper understanding as a result of such testimony and the narrative testimony of the witness was reported to be a key factor in the juror's acceptance that the witness was credible.

Key Words

Forensic Science, Expert Witness Credibility, Education, Jury Decision Making, Criminal Trials, Expert Testimony

Introduction

How jurors perceive expert witnesses who testify is an area of research interest to judicial stakeholders. In an adversarial system, such as that in the United States, a persuasive witness could change the course of the trial and potentially have a significant influence on jury decision making. Understanding what factors and attributes in the expert witness translate to credibility in the juror's mind is therefore valuable information for judges, attorneys and forensic scientists.

Early research on witness credibility indicates that witness's attire, wearing glasses, and carrying a briefcase influences how jurors judged the knowledgeability of the expert (Tanton, 1979). Most of the existing research in this area has focused on the perceptions mock jurors have of expert witnesses in simulated trial experiments. One such study found that as the expert witness's experience level increased so too did the juror perceptions of their credibility (Swenson et al., 1984). A more recent experimental study investigated jurors' perceptions of the importance of the scientific validity of the evidence, the witness's expertise and the expert's use of technology in analyzing the evidence. An interesting finding was that as the trial simulations became more ecological (closer to a real trial) there was an increase in the influence of the expert's experience on the perceived reliability of the evidence and that neither the scientific validity of the evidence or the expert's use of technology had an influence on jurors perceptions (Koehler et al., 2016).

Other studies have examined how judges perceive the credibility and persuasiveness of expert witnesses. When asked to rank in order of importance the experience, education, publications or previous expert testimony, the vast majority of judges ranked experience as most important followed by education, whereas publications and prior testimony had very little influence on perceived credibility (Shuman et al., 1994). Another study of judge's perceptions of expert witness credibility found that the communication style of the expert was most important. Judges found expert witnesses to be more persuasive when they spoke clearly, avoided the use of jargon or technical terms and those who appeared impartial (Freckelton et al., 1999).

Brodsky *et.al* reviewed the literature and found that juror's descriptions of credibility of expert witnesses could be condensed into four main categories; likability, believability, trustworthiness and intelligence (Cramer et al., 2009) where likability was found to be the most

significant factor which influenced the juror's perception of trustworthiness of the expert witness (Cramer et al., 2009).

A disadvantage of the current body of research however is that most has been based primarily on mock juries, and in a limited capacity on real juries. Previous research on the perceptions of real jurors after real trials where physicians, accountants, biochemists and engineers testified as expert witnesses found that jurors placed more weight on testimony of witnesses who did not use technical language and offered firm opinions (Hastie, 1993, Champagne et al., 1991). The available literature also indicates that real jurors consistently find the expert's professional experience to be the greatest factor in determining their credibility over factors such as lack of bias or impartiality and academic education (Blackwell and Seymour, 2015, Sundby, 1997, Schutz, 1997, Schweitzer, 2016). It has also been shown that jurors were more likely to find expert witnesses credible when they used demonstrative aids such as charts (Gutheil, 2000). When jurors did not understand the expert's testimony, they have been shown to take heuristics, or mental shortcuts relying on the appearance and communication skills of the expert as a measure of their credibility (Rosenthal, 1983).

It is highly likely that the credibility of the expert witness is based on multiple factors rather than one single factor. This research explored this area in some depth and with real jurors rather than under conditions of simulation. The study attempted to answer the research question, "What factors influence how real jurors judge the credibility of forensic science expert witnesses?"

Methodology

Research Method

A parallel convergent exploratory mixed methods design (Figure 1) was used to attempt the answer the research question. This type of mixed method research design was chosen as it fit the confines of the study, as both the survey and interview questions needed to be judicially approved in advance of contacting the jurors. All of the factors which might influence a juror's perception of an expert witness were not known at the beginning of this study it fell within the exploratory category. This research approach involved watching the expert witnesses and jury

during the trial, collecting the quantitative and qualitative data within 1-2 weeks of each other (parallel convergent), analyzing the data and interpreting the qualitative and qualitative data simultaneously.

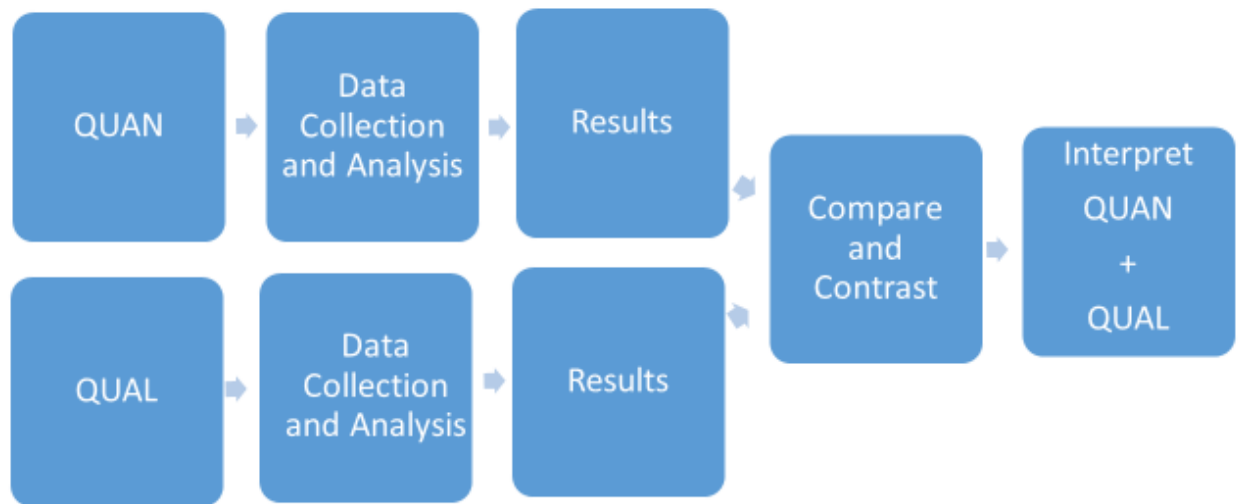


Figure 1: Parallel Convergent Mixed Method Approach

Participants

The sample population for this study were jurors who heard forensic science testimony in homicide trials in the State of Maine. Maine is the most northern state on the east coast in the United States of America and has a population of 1,335, 907 (Bureau, 2017). There were 29 jurors who participated in the survey and of these, 22 participated in the follow-up phone interviews. Males made up 45% of the survey participants and 50% of the phone interviewees. The jurors ranged in ages from 18 to 65+ with the average age for phone interviewees being in the 45-54 age category. Of the jurors who participated in the interviews, 86% reported being married, in common law partnerships, civil partnerships or cohabiting and 52% reported having earned a 4 year undergraduate degree or higher.

Data Collection

The data collection was carried out over a 24 month period from July 2014 to July 2016. The data collection tools (survey and interview questions) were developed and the judicial approval was sought and received by the Chief Justice of the State of Maine (U.S.A) Superior Court. The researcher attended nine trials, observed and took field notes when forensic science testimony was given by experts. The only experts observed were those who were called by the prosecution as these were the only forensic science witnesses whose appearance date at the trial was scheduled in advance, making the testimony observation possible. After the verdict was delivered the jurors remain empaneled in Maine for another 30 days. After this time a survey was posted to 144 jurors and alternate jurors. Jurors (N=29) returned the survey to the researcher and a subset of these jurors (N=22) participated in phone interviews giving a response rate of 20% and 15% respectively. All jurors who responded were included in the sample. To ensure juror confidentiality and anonymity, jurors were given pseudonyms. Pseudonyms of individuals who were jurors in the same trial were given names that began with the same letter. The data were then organized and analyzed. Figure 2 outlines the research process.

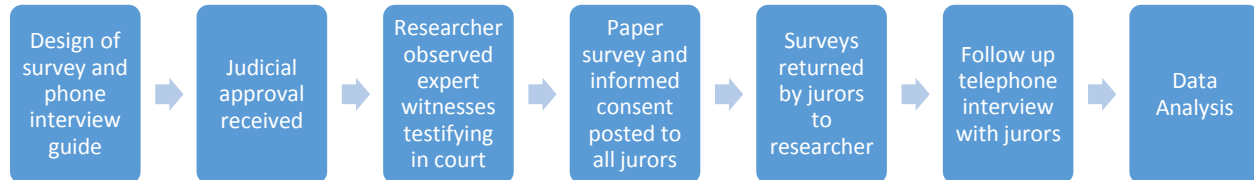


Figure 2: The Overall Research Process

The Researcher

The interviewer was female, worked as an assistant professor and had no prior relationship with the participants. The interviewer held a Master's degree in forensic science and had worked as a latent print examiner (full time and later as a consultant) for 14 years. The participants were not informed of the interviewer's forensic science background.

The researcher was interested in addressing the gap in the literature highlighted in the United States National Academy of Science, National Research Council report "Strengthening Forensic Science in the United States: A Path Forward (2009)" where it was reported that "jurors

use and comprehension of forensic evidence is not well studied” (National Research Council, 2009).

Researcher bias is an inherent concern in qualitative research, where the researcher themselves analyses and interprets the data and forms conclusions. Bias was minimized in this study by developing a series of structured interview questions and making these questions the backbone of the interview. In phenomenological research, such as this, as well as all qualitative research, it is important to allow the subject being interviewed to express freely their experience of the phenomenon and that was done throughout this work. When jurors veered away from the question asked the resultant side stories are also of great value and provide a rich vein for gaining understanding of the experience of the juror.

Instrumentation and Data Analysis

Quantitative Data

The quantitative data were organized, stored and analyzed using Microsoft Excel (2013). The data in the frequency tables and the charts were generated in Excel and the more advanced statistical calculations were carried out using IBM Statistical Package for the Social Sciences (SPSS, version 21). SPSS was used to determine if there were correlations between variables and their level of significance. If a juror did not answer a question on the survey the missing data reduced the sample size and statistical significance of the inferences between variables.

Qualitative Data

The vast majority of the qualitative data came from phone interviews with 22 jurors. Phone interviews were carried out using Skype® (version 7.33.01.104) with the plug-in Vodburner® (version 1.1.0.203). Vodburner recorded the calls and these were transcribed using an online service. The phone calls lasted from 32 minutes to 72 minutes and the length depended on the responses the jurors gave. The interviews were structured by the particular questions that were asked of each juror, but jurors were given flexibility to speak for as long as they needed to. A great deal of data was generated by allowing this free flow of information. The questions

asked during the phone interviews (Appendix B) gave a deeper meaning to the quantitative data and helped answer the research question posed at the beginning of this research.

The process of data analysis in this phenomenological phase was a cyclic one, meaning that the analysis of statements and coding of key phrases was constantly evaluated and re-evaluated. This was done by the primary investigator and reviewed by a second researcher. In order to minimize bias while undertaking the iterative process of developing themes, the primary investigator made a conscious effort to bracket any epoché (to suspend judgement) held regarding the jurors' perceptions of factors that influence decision making (Moustakas, 1994).

The qualitative data were organized in Nvivo (version 11) and analyzed in four steps. The first step was to organize the jurors' responses by the question asked during the interview. This was done by making each question a node. This grouped all the responses to the same question and allowed a general sense of the jurors' perceptions regarding the expert witnesses at the trials to be formed. The next step was to organize the jurors' responses into broad categories based on the goals of the research. Given the gap in the literature for research involving real jurors, it was essential for the researcher to analyze the qualitative data for new and emerging themes.

Determining what is an adequate sample size in qualitative research is not well defined and is often measured in terms of data saturation. This is the point in the research where there are no new themes or perspectives related to the research question (Brod et al., 2009) and the literature suggest this can happen as early as 6 in-depth interviews and on average with 12 interviews (Guest et al., 2006). The 22 in-depth interviews in this particular study and the analysis of the themes and repeating juror perspectives suggest data saturation was achieved.

Results

During the study, a set of questions was asked which specifically related to the jurors' perception of the forensic science witnesses. These included both survey (Appendix A) and interview questions (Appendix B). The purpose was to elucidate responses which would provide information relating to how the jurors' valued both the expertise and experience of the expert and to seek information on factors which might influence their perceptions of the expert's credibility.

Jurors' Definition of an Expert Witness

The jurors defined an expert witness in multiple ways but many definitions contained common descriptors such as '*knowledgeable*' and '*specialized*' and as someone who had '*received training*'. A few jurors indicated that a certain amount of experience was necessary to truly be considered an expert witness. "Justin" described a forensic science witness as:

"Somebody ...who has training. To me it's important to have a college background, scientific background. If you're going to be analyzing data, you need to understand statistics and also processes and knowing what procedures are and following them. Just because somebody takes a six weeks course doesn't really, to me, qualify them as an expert."

and "Gail" described experience as important:

"somebody with a lot of experience, has been working in it for quite a while".

For some jurors, credentials and certifications were an important part of the definition of an expert witness. "Gillian" expected forensic science experts to have:

"licenses or certifications pertaining to that field"

and "Matthew" said experts should have:

"credentials or certificates of competency".

Qualifications, Training and Certifications of an Expert Witness

One question on the survey question (Appendix A, question 4) asked jurors (n=25) to rate, in order of importance the qualifications and background criteria for an expert witness. The results combined across all 25 jurors are presented in Figure 3.

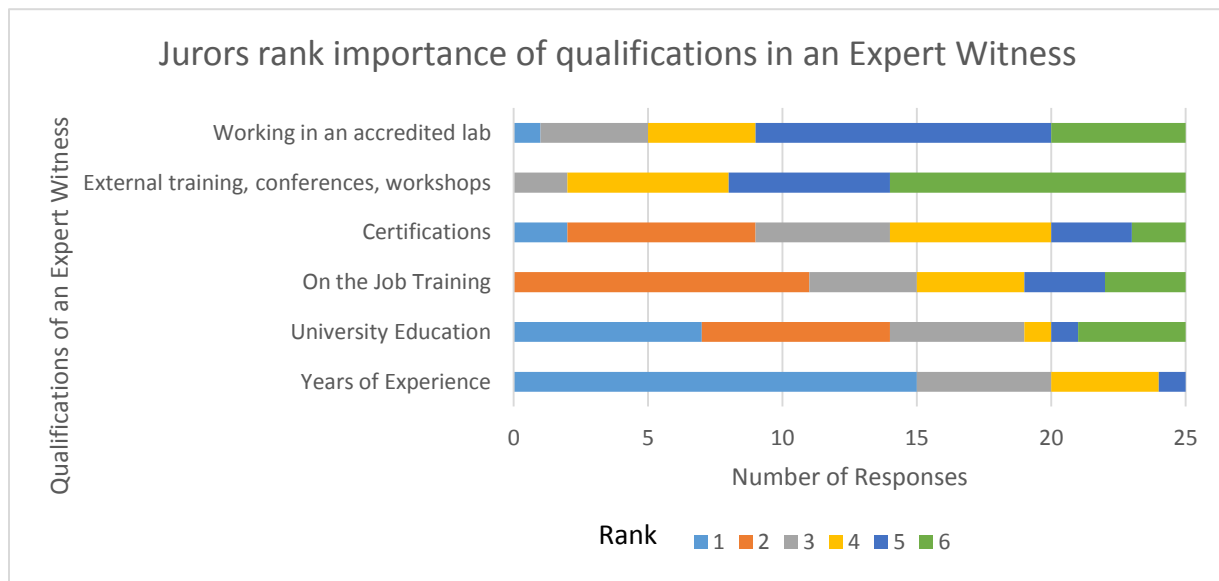


Figure 1: Jurors' interpretation of the importance of qualifications in an expert witness (Rank: 1= Most Important, 6= least important)

There was no one qualification that all jurors found important. Years of experience was ranked in the top 3 by 80% of the jurors, university education was ranked in the top 3 by 76% of the jurors and on the job training was ranked in the top 3 by 60% of the jurors. Less important to the jurors was whether the expert worked in an accredited lab or the expert's external training. 80% of the jurors ranked "working in an accredited lab" in the lower three positions and 92% of jurors ranked external training in the lower 3 positions. (Table 1).

Table 1: Importance of qualifications in an expert witness

	Rank in importance		
	Most	Least	
	1&2	3&4	5&6
University Education	14 (56%)	6 (24%)	5 (20%)
On the Job Training	11 (44%)	8 (32%)	6 (24%)
Certifications	9 (36%)	11 (44%)	5 (20%)
Years of Experience	15 (60%)	9 (36%)	1 (4%)

Working in an accredited lab	1(4%)	8(32%)	16(64%)
External training	0	8 (32%)	17 (68%)

(red = below 25%; orange= >30-59%; green =>60%)

The data may have been influenced by the jurors' perceptions of higher education, where over 80% ranked experience and education high irrespective of whether they themselves had attained education beyond the high school level. A univariate analysis was calculated for university education and years of experience using a Pearson correlation coefficient. There is moderate inverse correlation between a juror's ranking of university education and their ranking of years of experience ($r = -.552$, $N=25$, $P=.01$). Jurors who tended to rank university education high also tended to rank years of experience low, and vice versa. This data is illustrated in Table 2.

Table 2: [Correlations of the ranking by Jurors of an expert witnesses qualifications](#)

	University Education	On the job training	Certifications	Experience	Working in an accredited lab	External Training: Conferences/ workshops
University Education	1	-.299	-.051	-.552**	-.196	.163
OJT	-.299	1	-.511**	-.060	-.127	-.155
Certifications	-.051	-.511**	1	-.189	-.166	-.078
Experience	-.552**	-.060	-.189	1	-.231	.300
Working in an accredited lab	-.196	-.127	-.166	-.231	1	-.237
External training: conferences/ workshops	.163	-.155	-.078	-.300	-.237	1

**Highlighted areas indicate correlations which are significant at the 0.01 level (2-tailed)

The same was true for the correlation between on the job training and certifications

($r = -.511$, $N = 25$, $P = 0.01$). Jurors who ranked on the job training high tended to rank certifications low. This appears to indicate that jurors either put weight on formal education of the expert witnesses, such as certifications and university education and placed less value on the job training and years of experience, or vice versa.

In response to the interview question “Which is more important in an expert witness, qualifications, such as education or certifications or years of experience?” (Appendix B, question 3) the majority of jurors, 63%, stated that years of experience was more important in an expert witness than qualifications (Figure 4) supporting the data derived from the paper survey.

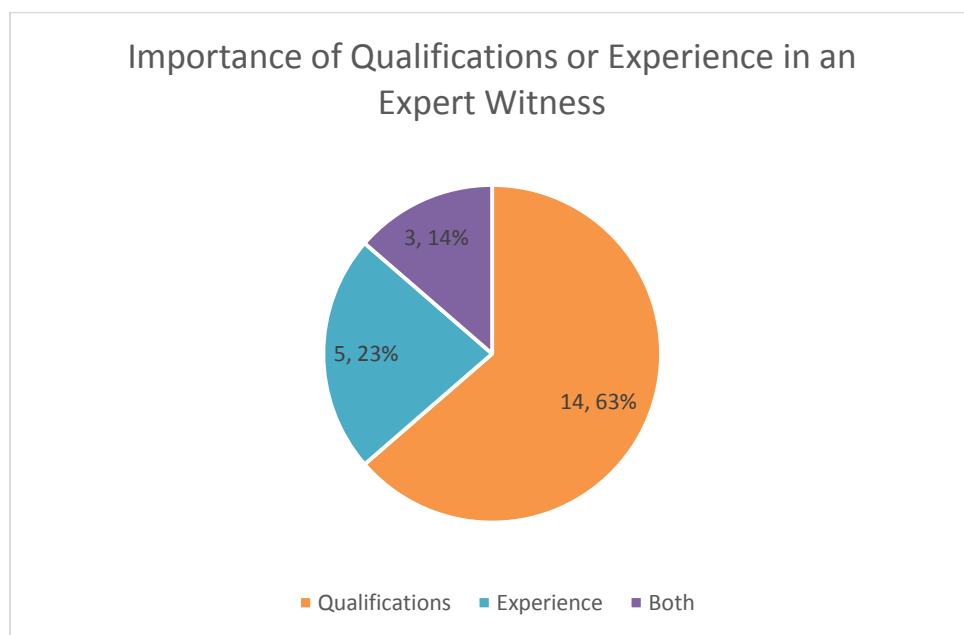


Figure 2: Jurors’ evaluation of the importance of formal qualifications vs. years of experience

Jurors thought experience was the most important factor in an expert witness and explained that although education and certifications are important for a forensic scientist, they felt that it was the application of this knowledge (through job experience) that led to expertise. “Amy” stated:

“I think there are some people who can get many certifications and take many courses and classes, but they can't actually apply it and have never applied it. I

think there are people who have developed significant experience in the subject matter from just seeing, doing, being around it, being around other people”.

Jurors described the value of experience in terms of the variety of evidence types a forensic scientist might be called on to analyze. “Amy” said that a person with experience would be better than a person with only qualifications when the evidence was complex or outside of what might be expected:

“(forensic scientists) having a sense of what the norm would be and things that would not necessarily be the norm.”

“Dana” described the benefit of experience to the forensic scientist as:

“Highly qualified people do not necessarily have the vast experience to know what is average or extraordinary or usual”.

“Dorothy” felt experience allowed the scientist a range of approaches when examining evidence:

“because every case is a little bit different, and I think that there's more flexibility in experience. (Evidence is) not as standard as stuff you get from the textbook”.

Some of the jurors related the value of experience back to their own professions and job experience. There was an understanding among jurors that forensic science as a profession cannot be learned solely from books. “Lloyd” said;

“I'm an accountant. When I started accounting, even though I had learned all this stuff, actually seeing it in practice the first time ...things are a little different than what you see in the book. You have to be able to recognize that. I would say that experience is probably, with the proper qualifications or the training, experience would be more important than the qualifications”.

“Larry” explained the value of experience by relating it to a life event:

“I would say years of experience, and here's a good example. My wife was seeing a medical specialist and saw him for several years, and he had qualifications. He had certificates and he had fancy diplomas, and he lost his medical license because he didn't know what ... he was doing. I would much rather, someone in a very serious professional field, I would much rather have someone that had a lot of experience and was competent.”

The challenge for new forensic scientists in qualifying as an expert in court will be to describe their qualifications and also how they have learned the discipline through supervised casework or other internal training. “Harold” explained:

“For example, if someone were soon out of college, I don't know that they're going to be an expert witness but they do have the necessary education to get them there. Some of those things go hand in hand. Experience is very important but their upbringing or background enters into it as well. I would think that a journeyman so to speak would be working with an expert witness and would become an expert witness over time based on both education and then experience in the career.”

A few jurors described the connection between experience and qualifications. To gain experience you need qualifications and to gain credentials you need experience. Certification in many of the different forensic science disciplines requires the scientist to have a certain minimum number of years of experience, so it is true that credentials such as certifications require experience as well. “Ann” said:

“it's hard for me to almost differentiate them because my assumption would be if they're credentialed in anyway, that that process means that they do have experience. I guess I would say credentials, assuming that that comes along with

some kind of procedure, or protocol, before they are credentialed that would involve experience.”

“Gillian” also felt that experience and qualifications went hand-in-hand:

“I think it varies because, well, personally I say both in order gain the qualifications you have to have the experience”.

For the most part the jurors valued both experience and the formal qualifications of the expert witnesses. “Grace” described why she thought both education and experience were important in an expert:

“I think both are important but a person wouldn't be reliable if they didn't have the proper qualifications and I think that's just the standardized way of demonstrating someone's expertise in the field is usually if they have a certain credential there. They're passing the test but they're also certified at that level by having years of experience. Someone doesn't just pass the test and become a Medical Examiner. They're supervised and they're given feedback. To me, the qualification supersede experience because it include experience.”

When speaking of the importance of qualifications jurors focused on the value of foundational knowledge needed by a forensic scientist that the jurors described should be based on education and other credentials. “Justin” described expertise in terms of his own experience as an engineer:

“I guess for me qualifications. I'm an engineer and the only way that I could get my professional engineering license was by having a certain number of years of experience. Then I'd have to have other professional engineers sign off that they've observed me and witnessed my performance. I'd have to have a certain

amount of education in order to pass. I think qualifications is higher than experience”.

Judging the Credibility of the Forensic Science Expert Witness

Jurors were asked in the survey to rate the credibility, in their view, of the expert witnesses that they watched during the trial. The jurors who participated in the follow-up phone interviews were asked to describe how they determined if an expert witness was credible. Jurors rated all the expert witnesses they watched as being credible. Figure 5 illustrates the breakdown of the evaluation of credibility across all of the expert witnesses. 99% of the jurors felt that the expert witnesses were either very credible (54%) or Credible (45%).

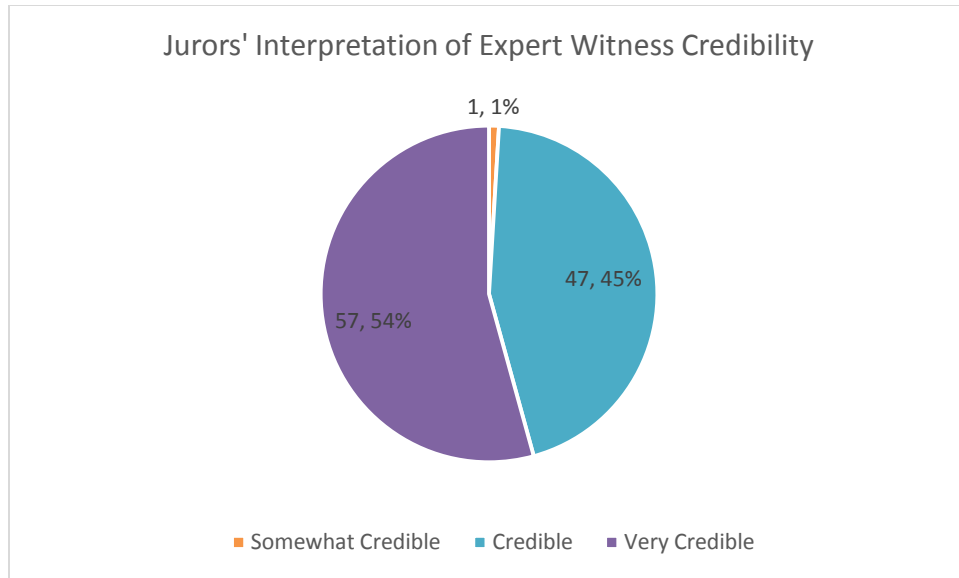


Figure 3: How jurors rated credibility of all expert witnesses who testified at their trial

Qualifications

Jurors described their view of the expert witnesses' credibility based on the experts' qualifications. Each time a forensic science expert witness testifies in the State of Maine they answer questions asked by the attorney who called them. This gives the court an opportunity to decide if the individual is an expert for the purposes of the trial. This process gave credibility to the expert witnesses. "Grace" explained:

"I believe that they were credible when they went through and introduced their background. They wouldn't just come up and start answering questions. They would begin by ... Well, actually it was from a question. The first question would be describing your background or qualifications or credentials. When they described that aspect, that's what sold me in trusting what they had to say."

"Lloyd" stated how he determined credibility of an expert witness as:

“the lawyers explain that, their background and their experience. We basically relied on that”.

“Barry” specifically commented on the testimony of the medical examiner:

"I remember specifically there was one guy, and I believe he was a doctor from the Maine State Crime Lab. The wounds that were inflicted to the victim, weren't self-inflicted..., I guess knowing he's a doctor, he had ... He gave his qualifications. He'd been working for the Maine State Crime Lab for a long time. I don't remember exact years, but I think knowing he obviously has hundreds of hours, I think that those are all important."*

*The medical examiner works for the Maine Attorney General's Office, not the Crime Laboratory.

Confidence and Demeanor

The most common reasons jurors gave to describe how they evaluated an expert witness' credibility was based on the expert's demeanor and their confidence on the witness stand. “Gillian” described how she based credibility on:

“their knowledge of fields and their confidence on the stand”.

“Gary” described the credibility in the same trial as:

“demeanor, I guess, to a degree. Good old fashioned judge of character. Sometimes the defense tries to get under their (expert witnesses) skin, so to speak, and you can see how people react, and you can see a seasoned veteran sometimes by that. I saw that first hand at the ...case.”

“Alana” commented on both prosecution and defense experts:

“You could tell the ones that were trying to just spin a line and the ones that were the honest ones and that were real sincere about their job and or the ones that were trying to avoid [sic] the answering (the question).”

“Justin” described how confidence and credibility were connected to how well an expert could answer difficult questions;

“It does influence your perception of the person, how they come across, if they’re back tracking or they’re tripped up by the lawyer and try to answer it, instead of just saying I’m not sure about this or if it sounds like a contrived answer then that kind of sways my thinking about what the person (expert) is saying.”

Experts being put forth by the Government

Some jurors appeared to believe that credibility automatically applied to any expert accepted by the judge. “Grace” believed the expert witnesses were formally licensed as forensic scientists and as expert witnesses. At this time forensic scientists in the State of Maine are not licensed and the decision to allow an individual to testify as an expert rests with the judge alone.

“They (expert witnesses) were licensed by the State of Maine to do the work that they did.”

It is to be expected that jurors who are unfamiliar with the role of forensics scientists and the responsibility of the judge as the gatekeeper might place undue weight on the credibility of an expert just because they work for the government. “Justin” explained it as:

“There is a whole level of inherent trust that you tend to apply to someone who comes forward that is brought to the case from the government.”

“Matthew” expressed how he determined credibility:

“I think that if you are employed by the government of Maine, I'd like to think that they're only going to hire people that know what they're talking about.”

For many professions in Maine and across the United States, licenses and certifications are necessary to perform business. Examples include hairdressers, barbers, tax accountants, nurses and doctors. This is not the case currently for forensics scientists. “Larry”, and possibly others, inferred that since licenses required in other industries, forensic scientists were also licensed.

“I would have to first feel comfortable that the party introducing them to me is credible and then that I have trust in whoever is coming. I work in a field, here in my job where an engineer puts their stamp on something, they're speaking on behalf of an industry standard or whatever. They're actually liable personally for what they're saying. I would hope that if we had an expert witness talking about whatever, I heard all kinds of them. I guess, myself knowing industry standards, I would make the, and I hate to use the word assumption but I will, assumption that they're speaking on behalf of their field of expertise and I would like to believe that they are offering credible information rather than tainted information. The experts were acting as representatives of the state of Maine rather than some private hire for the gun industry, or something. My opinion was that they had to be credible to serve doing the functions they were for the state.”

How the Expert Witness Explained the Evidence

Many of the jurors explained that credibility was tied to how the expert witness explained the evidence they were called to testify about. Expert witnesses know it is important to make sure the scientific evidence is accessible and understandable to the lay juror. This brings to light the fact that the ability of the expert to explain the scientific evidence is tied to credibility in the juror's mind. "Martin" explained credibility this way:

"as they have a conversation about their area of expertise, how did they explain it? Were they explaining in a way that they had a command of the information and yet they could explain it to lay people and the jury in a simple way?"

"Gregory" explained credibility in almost the same manner:

"I think their ability to explain ... On the scientific side of it, their ability to explain what they're talking about in layman's terms."

The jurors expect the expert witness to present in a clear manner and also expect the testimony to be engaging. "Harold" stated that credibility was based on:

"how they come across, their personality. Some people can be experts and be very rigid and stuffy and whatever and other people have come across quite naturally and I think that's a part of (credibility)".

Style of Testimony and Definitiveness of Conclusions

During the interview jurors stated that they appreciated when the expert witnesses used visual aids (forensic pathologists, fingerprint examiners, physical match examiners and tool mark examiners). The forensic pathologists used traditional poster presentations. These posters

explained where particular wounds were documented on the victim's body. The tool mark, fingerprint and physical matching experts used PowerPoint type displays to help explain their conclusions.

"Harold" commented that he based the credibility of a tool mark examiner on her style of testimony where she demonstrated a comparison between a wrench and a skull fracture:

"She was able to show that she believed that one fracture was caused by the front of the wrench, one was caused by the back of the wrench and one was caused by the side of the wrench where you could actually see the threads from the adjustable screw. I was totally impressed with that woman, but she did say...she couldn't say beyond a shadow of a doubt that that was what happened. She just blew me away and then I just believed the woman."

"Martin" also described that a visual display of the evidence lent to the credibility of the testimony:

"the visualality (sp) of that evidence. What I mean by that is the forensic team explained and did a 360 degree visual pictures of everything".

"Damon" described the presentation of the evidence at the trial as being very important to him in determining the credibility of the testimony of the medical examiner who testified about a gunshot wound in the victim's body:

"a picture of a neck and then (he) showed that going through it at this angle and then draw it in one more view, of the front view, then you could get the idea where that was going through."

"Justin" explained that the credibility of a crime scene examiner depended on how he demonstrated the evidence found at the entry point (on a door) in court:

"Justin": *This is a simple example, but they showed the backdoor before they took it off and they actually had brought the door to the evidence room. You could see that some markings were the same and it wasn't just a person*

saying that. The door was also a picture on the home that kind of backed it up.

Researcher: *They brought the door to the court?*

“Justin”: *Yes, they did, yeah. They showed us the knife marks and stuff.*

Researcher: *Okay. My next question is ... Sorry, go ahead.*

“Justin”: *For me it takes more than just someone’s word to incriminate somebody to make it a fact.*

In reference to a homicide scene where bloodstains were found in multiple rooms of the home and the defense put forward a theory that the defendant was acting in self-defense “Matthew” described how he based the credibility of a blood spatter expert on their ability to explain the blood stain patterns found at the crime scene through verbal testimony and the use of crime scene photographs.

Researcher: Okay. Perfect. What makes you think an expert witness is credible? If you think back to the trial, when you saw the scientific witnesses, how did you know if they were credible or not?

“Matthew”: Well, that's a good question. I guess I can use this one as an example. They had blood spatter ... What's the term ... But those that specialize in blood spatter, so they can tell which way a blade (of a knife) was being thrown, forward or backward or what, and I guess just, in general, science has proven that to be true, the way that they present it to you.

When forensic scientist’s testified about the evidence it was clear that some expert witnesses developed more of a rapport with the jury than other witnesses. When the expert witness played more of an educator’s role and took the time to teach the jurors a little about the science and how they came to their conclusions the jurors appeared to be more engaged. Jurors nodded their heads, made a lot of eye contact with the expert and

looked at their fingers during the testimony of the fingerprint experts. “Amy” described how she determined if an expert witness was credible:

“I think being confidence, being able to answer questions in detail, and being able to bring it down to a level for other people to understand it. I think almost like teaching, people who have a good knowledge base of the subject matter are able to look at their audience and teach the subject. Some people who just spout off key phrases without being able to explain or having any knowledge about detail I think tend to not be as credible as other people who have more subject matter detail”

Jurors mentioned that they did not understand DNA evidence and that this lack of understanding may have influenced their overall rating of the witness’s credibility. The footwear and tire mark evidence experts testified to class characteristics associations and not individualizations or ‘matches’. They testified that the crime scene impression(s) and known shoes/tires had the same pattern but could not be more specific in their conclusions.

“Charlotte” stated:

“The tire tracks, I think that it is more difficult, it’s not always clear cut, if it actually was the specific tire”.

Figure 6 illustrates the spread of jurors’ rating of expert witness credibility across the disciplines. Apart from the fingerprint examiners, all of the other expert witnesses were rated very credible or credible by the jurors.



Figure 4: Jurors' Interpretation of Expert Witness Credibility

Conclusions

The jurors in this study defined expert witnesses as “knowledgeable” and as people who had received “specialized training”. When asked to rank qualifications of an expert witness, more jurors ranked experience in the specialized area as “most important” than those who ranked university education as “most important”. On the job training and certifications were slightly less important to the jurors and of least importance were continuing education such as attending workshops and conferences or whether or not the laboratory the expert worked in was accredited. This research is consistent with other studies which found that jurors place a lot of weight on the expert’s experience (Koehler et al., 2016, Blackwell and Seymour, 2015, Swenson et al., 1984, Schweitzer, 2016) and that university education is slightly less important to them (Schutz, 1997, Cooper et al., 1996). Many of the jurors stated that they believed both were very important.

These findings may be important for crime laboratory management and those who hire and retain scientific experts. If jurors place a lot of weight on the experience of the expert, then forensic scientists with only a few years' experience will have to highlight their other qualifications (e.g. on the job training, certifications and university education) to the jurors when qualifying as an expert.

Currently, the United States Federal government is moving forensic science towards universal standards in processing methodologies, conclusions and ultimately to national credentials for forensic scientists. These are important steps in promoting quality in forensics science, but jurors are evaluating the expert witness on their experience and expertise. In the future laboratory accreditation may be necessary to apply for and secure federal funding. While these policies and procedural changes are a step in the right direction for forensic science it is very important to keep the jury in mind. This research suggests that expert witnesses should make jurors more aware of the benefits of laboratory accreditation and continuing education of expert witnesses.

The credibility of an expert witness can be defined as how persuasive that person is when they give testimony (Ivkovic, 2003, Pope et al., 2006). Pope suggests that credibility is related to the expert's "authoritativeness, character, competence, attractiveness and expertness" (Pope et al., 2006). Understanding how jurors interpret witness credibility is important as it has been shown to influence perceptions of evidence reliability and verdicts (Cramer et al., 2009, Ivkovic, 2003). This research supports the previous studies which identified likeability, believability, trustworthiness and intelligence as being the main factors which influence jurors' perceptions of forensic science expert witnesses (Brodsky et al., 2010). In this study the jurors described that the expert's confidence and demeanor when testifying were the most important factors in determining their credibility as a witness. Jurors also used the number of years' experience the expert witness had gained, as well as their qualifications, to establish credibility. Sometimes prosecution or defense lawyers will offer to stipulate to the witness's expertise to save time during the trial or to minimize their ability to gain credibility with the jury. This research indicates that the process of qualifying an expert before testimony about the evidence begins is a necessary and very important for the expert and the jury.

Of some concern to the justice system may be the responses from jurors who based the expert witness's credibility on the fact that they were governmental employees or that they were presented by a prosecution attorney. Defense attorneys need to be aware that jurors may place additional confidence in experts employed by the government and may choose to highlight that history had shown that governmental laboratories do make mistakes (Garrett and Neufeld, 2009).

This study supports previous research which indicates that experts appear more credible to the jury when they take the time to teach the jury about how they came to their conclusions and supported their testimony through the use of demonstrative aids (Rosenthal, 1983, Gutheil, 2000, Blau et al., 2017). If the evidence or the expert's conclusions can be demonstrated using a visual aid this will likely aid the jury's understanding and in turn increase the perception of the expert's credibility.

The results of this research were based a narrow sample of jurors (Maine jurors, called by the prosecution in homicide trials) and caution needs to be exercised with how these results reflect on jurors in general. This type of research on real jurors observations of forensic science testimony should be repeated and consideration given to experts called by the defense and trials where the defendant is charged with a lesser offense. Every effort was taken to minimize researcher bias but it is a concern in all qualitative studies. The coding of the data by the researchers may have influenced the interpretation of the results and as such further research in this area is needed.

Due to the size of the sample, all jurors who responded to the request to participate in the research were included. This self-selected, non-randomized, population of jurors may not represent jurors as a whole. Research involving post trial surveying and interviews of jurors will always have limitations. It is very difficult to get the perfect sample that can represent the greater population. These limiting factors should be considered when applying these results to other populations and circumstances.

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Appendix A

Please answer the following questions about yourself and the trial where you were a juror or alternate.

1. What is your gender?

- ☐ Male
- ☐ Female

2. How old are you?

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ 65+

3. What is the highest level of education you have completed?

- ☐ Less than high school
- ☐ High school/ GED
- ☐ Some college
- ☐ Two year college degree (Associate)
- ☐ Four year college (BS or BA)
- ☐ Master's degree
- ☐ Doctoral degree

4. List in order of importance (6= least importance, 1= most importance) the most important qualifications of an expert witnesses

<input type="checkbox"/>	University Education
<input type="checkbox"/>	On the job training
<input type="checkbox"/>	Certifications
<input type="checkbox"/>	Years of experience
<input type="checkbox"/>	Working in an accredited laboratory
<input type="checkbox"/>	External training, such as conferences, workshops

5. With regard to (insert Expert witness name and brief description to the content of testimony) how credible (believable) was his/her testimony?

- ☐ Not credible
- ☐ Somewhat credible
- ☐ Credible
- ☐ Very credible

6. How effectively did the (forensic scientist e.g. firearms examiner) explain to you how he/ she came to his /her conclusions?

- ☐ Poor Job
- ☐ Fair Job
- ☐ Good Job
- ☐ Great Job

7. Did the chart/ demonstration/ media presentation help you understand the subject matter (e.g. bullet trajectory?)

- ☐ Not at all
- ☐ To some extent
- ☐ To large extent

Appendix B

Phone interview questions

1. I would like to go back to one of the questions on the paper survey, the question stated list in order of importance the qualifications of an expert witness, University education, on the job training, certifications, years of experience, working in an accredited lab and external training such as conferences/workshops. Ask juror to confirm their order that they put on the paper survey

2. Ask them to define what an expert witness is then ask: What makes you think an expert witness is credible?
3. Which is more important in an expert witness qualifications or experience and why?
4. Did you feel that you didn't understand any of the scientific evidence and if so what would have helped?

Original Research Article

Title:

Jurors' perceptions of Forensic Science Expert Witnesses: Experience, Qualifications, Testimony Style and Credibility

Abstract

The judicial system calls upon expert witnesses to testify in court when complex or specialized knowledge, beyond that of the lay person, is needed to interpret the evidence. Previous research has indicated that particular traits of the expert witness can affect their credibility in the eyes of the jury, however most of this research has been undertaken using mock jurors. In contrast, this study investigated the perceptions of real jurors. In particular, the research focused on the juror's perception of the forensic scientists' expertise and credibility during testimony in homicide cases. Data was gathered from jurors after nine homicide trials using both questionnaire (n=29) and direct one to one interviews (n=22). The jurors defined what they thought an expert witness was and what attributes were important in a forensic scientist. Jurors suggested that the expert witness's education and years of experience were more important than certification or laboratory accreditation. The jurors' perceptions of the credibility of the expert was based upon the academic qualifications of the expert, the confidence they portrayed in answering the questions ask of them, their demeanor and their status of being government employee.

The use of narrative language and demonstrative aids by the forensic science expert witness to explain the evidence was explored. Jurors described a deeper understanding as a result of such testimony and the narrative testimony of the witness was reported to be a key factor in the juror's acceptance that the witness was credible.

Key Words

Forensic Science, Expert Witness Credibility, Education, Jury Decision Making, Criminal Trials, Expert Testimony

Introduction

How jurors perceive expert witnesses who testify is an area of research interest to judicial stakeholders. In an adversarial system, such as that in the United States, a persuasive witness could change the course of the trial and potentially have a significant influence on jury decision making. Understanding what factors and attributes in the expert witness translate to credibility in the juror's mind is therefore valuable information for judges, attorneys and forensic scientists.

Early research on witness credibility indicates that witness's attire, wearing glasses, and carrying a briefcase influences how jurors judged the knowledgeability of the expert (Tanton, 1979). Most of the existing research in this area has focused on the perceptions mock jurors have of expert witnesses in simulated trial experiments. One such study found that as the expert witness's experience level increased so too did the juror perceptions of their credibility (Swenson et al., 1984). A more recent experimental study investigated jurors' perceptions of the importance of the scientific validity of the evidence, the witness's expertise and the expert's use of technology in analyzing the evidence. An interesting finding was that as the trial simulations became more ecological (closer to a real trial) there was an increase in the influence of the expert's experience on the perceived reliability of the evidence and that neither the scientific validity of the evidence or the expert's use of technology had an influence on jurors perceptions (Koehler et al., 2016).

Other studies have examined how judges perceive the credibility and persuasiveness of expert witnesses. When asked to rank in order of importance the experience, education, publications or previous expert testimony, the vast majority of judges ranked experience as most important followed by education, whereas publications and prior testimony had very little influence on perceived credibility (Shuman et al., 1994). Another study of judge's perceptions of expert witness credibility found that the communication style of the expert was most important. Judges found expert witnesses to be more persuasive when they spoke clearly, avoided the use of jargon or technical terms and those who appeared impartial (Freckelton et al., 1999).

Brodsky *et.al* reviewed the literature and found that juror's descriptions of credibility of expert witnesses could be condensed into four main categories; likability, believability, trustworthiness and intelligence (Cramer et al., 2009) where likability was found to be the most

significant factor which influenced the juror's perception of trustworthiness of the expert witness (Cramer et al., 2009).

A disadvantage of the current body of research however is that most has been based primarily on mock juries, and in a limited capacity on real juries. Previous research on the perceptions of real jurors after real trials where physicians, accountants, biochemists and engineers testified as expert witnesses found that jurors placed more weight on testimony of witnesses who did not use technical language and offered firm opinions (Hastie, 1993, Champagne et al., 1991). The available literature also indicates that real jurors consistently find the expert's professional experience to be the greatest factor in determining their credibility over factors such as lack of bias or impartiality and academic education (Blackwell and Seymour, 2015, Sundby, 1997, Schutz, 1997, Schweitzer, 2016). It has also been shown that jurors were more likely to find expert witnesses credible when they used demonstrative aids such as charts (Gutheil, 2000). When jurors did not understand the expert's testimony, they have been shown to take heuristics, or mental shortcuts relying on the appearance and communication skills of the expert as a measure of their credibility (Rosenthal, 1983).

It is highly likely that the credibility of the expert witness is based on multiple factors rather than one single factor. This research explored this area in some depth and with real jurors rather than under conditions of simulation. The study attempted to answer the research question, "What factors influence how real jurors judge the credibility of forensic science expert witnesses?"

Methodology

Research Method

A parallel convergent exploratory mixed methods design (Figure 1) was used to attempt the answer the research question. This type of mixed method research design was chosen as it fit the confines of the study, as both the survey and interview questions needed to be judicially approved in advance of contacting the jurors. All of the factors which might influence a juror's perception of an expert witness were not known at the beginning of this study it fell within the exploratory category. This research approach involved watching the expert witnesses and jury

during the trial, collecting the quantitative and qualitative data within 1-2 weeks of each other (parallel convergent), analyzing the data and interpreting the qualitative and qualitative data simultaneously.

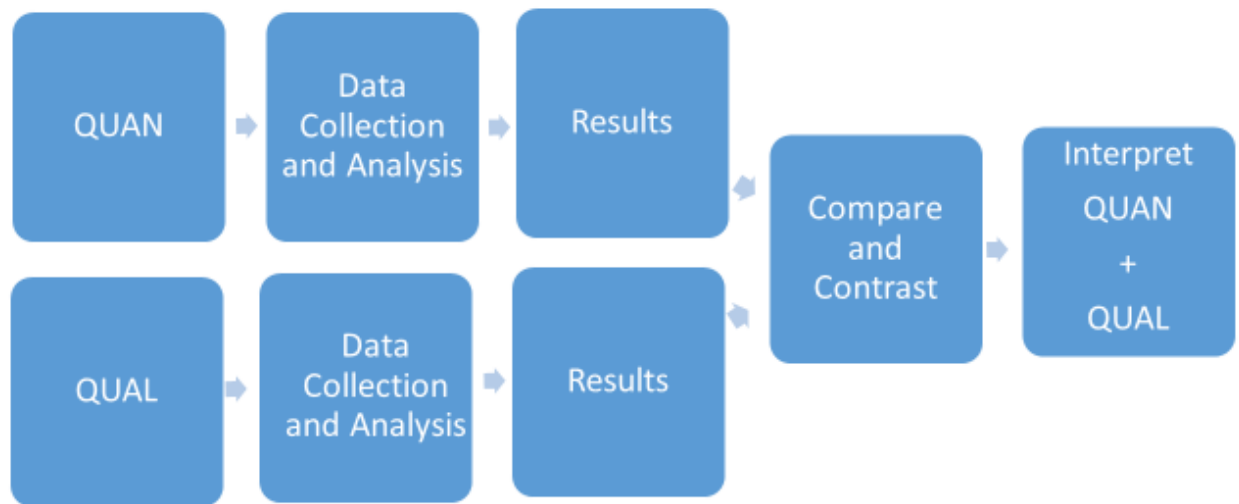


Figure 1: Parallel Convergent Mixed Method Approach

Participants

The sample population for this study were jurors who heard forensic science testimony in homicide trials in the State of Maine. Maine is the most northern state on the east coast in the United States of America and has a population of 1,335, 907 (Bureau, 2017). There were 29 jurors who participated in the survey and of these, 22 participated in the follow-up phone interviews. Males made up 45% of the survey participants and 50% of the phone interviewees. The jurors ranged in ages from 18 to 65+ with the average age for phone interviewees being in the 45-54 age category. Of the jurors who participated in the interviews, 86% reported being married, in common law partnerships, civil partnerships or cohabiting and 52% reported having earned a 4 year undergraduate degree or higher.

Data Collection

The data collection was carried out over a 24 month period from July 2014 to July 2016. The data collection tools (survey and interview questions) were developed and the judicial approval was sought and received by the Chief Justice of the State of Maine (U.S.A) Superior Court. The researcher attended nine trials, observed and took field notes when forensic science testimony was given by experts. The only experts observed were those who were called by the prosecution as these were the only forensic science witnesses whose appearance date at the trial was scheduled in advance, making the testimony observation possible. After the verdict was delivered the jurors remain empaneled in Maine for another 30 days. After this time a survey was posted to 144 jurors and alternate jurors. Jurors (N=29) returned the survey to the researcher and a subset of these jurors (N=22) participated in phone interviews giving a response rate of 20% and 15% respectively. All jurors who responded were included in the sample. To ensure juror confidentiality and anonymity, jurors were given pseudonyms. Pseudonyms of individuals who were jurors in the same trial were given names that began with the same letter. The data were then organized and analyzed. Figure 2 outlines the research process.

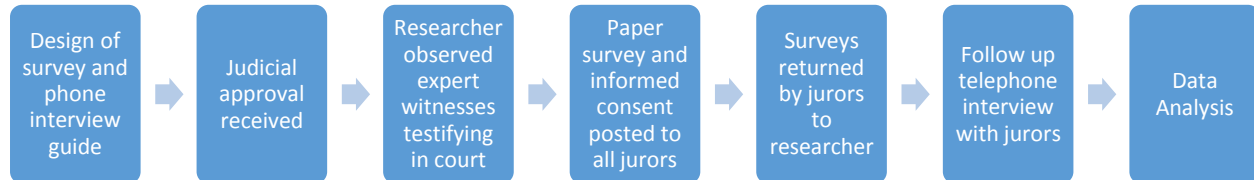


Figure 2: The Overall Research Process

The Researcher

The interviewer was female, worked as an assistant professor and had no prior relationship with the participants. The interviewer held a Master's degree in forensic science and had worked as a latent print examiner (full time and later as a consultant) for 14 years. The participants were not informed of the interviewer's forensic science background.

The researcher was interested in addressing the gap in the literature highlighted in the United States National Academy of Science, National Research Council report "Strengthening Forensic Science in the United States: A Path Forward (2009)" where it was reported that "jurors

use and comprehension of forensic evidence is not well studied” (National Research Council, 2009).

Researcher bias is an inherent concern in qualitative research, where the researcher themselves analyses and interprets the data and forms conclusions. Bias was minimized in this study by developing a series of structured interview questions and making these questions the backbone of the interview. In phenomenological research, such as this, as well as all qualitative research, it is important to allow the subject being interviewed to express freely their experience of the phenomenon and that was done throughout this work. When jurors veered away from the question asked the resultant side stories are also of great value and provide a rich vein for gaining understanding of the experience of the juror.

Instrumentation and Data Analysis

Quantitative Data

The quantitative data were organized, stored and analyzed using Microsoft Excel (2013). The data in the frequency tables and the charts were generated in Excel and the more advanced statistical calculations were carried out using IBM Statistical Package for the Social Sciences (SPSS, version 21). A Spearman Rho test was used to calculate the correlations of the ranked data which was collected through the survey (Appendix A, Question 4). This correlation test was used because the ranking value a juror assigned to a variable may not represent interval data. Ranking the variables only puts them in order of importance but does not account for how closely (or how far) these ranks are from each other in the juror’s mind. If a juror did not answer a question on the survey the missing data reduced the sample size and statistical significance of the inferences between the variables.

Qualitative Data

The vast majority of the qualitative data came from phone interviews with 22 jurors. Phone interviews were carried out using Skype® (version 7.33.01.104) with the plug-in Vodburner® (version 1.1.0.203). Vodburner recorded the calls and these were transcribed using an online service. The phone calls lasted from 32 minutes to 72 minutes and the length depended

on the responses the jurors gave. The interviews were structured by the particular questions that were asked of each juror, but jurors were given flexibility to speak for as long as they needed to. A great deal of data was generated by allowing this free flow of information. The questions asked during the phone interviews (Appendix B) gave a deeper meaning to the quantitative data and helped answer the research question posed at the beginning of this research.

The process of data analysis in this phenomenological phase was a cyclic one, meaning that the analysis of statements and coding of key phrases was constantly evaluated and re-evaluated. This was done by the primary investigator and reviewed by a second researcher. In order to minimize bias while undertaking the iterative process of developing themes, the primary investigator made a conscious effort to bracket any epoché (to suspend judgement) held regarding the jurors' perceptions of factors that influence decision making (Moustakas, 1994).

The qualitative data were organized in Nvivo (version 11) and analyzed in four steps. The first step was to organize the jurors' responses by the question asked during the interview. This was done by making each question a node. This grouped all the responses to the same question and allowed a general sense of the jurors' perceptions regarding the expert witnesses at the trials to be formed. The next step was to organize the jurors' responses into broad categories based on the goals of the research. Given the gap in the literature for research involving real jurors, it was essential for the researcher to analyze the qualitative data for new and emerging themes.

Determining what is an adequate sample size in qualitative research is not well defined and is often measured in terms of data saturation. This is the point in the research where there are no new themes or perspectives related to the research question (Brod et al., 2009) and the literature suggest this can happen as early as 6 in-depth interviews and on average with 12 interviews (Guest et al., 2006). The 22 in-depth interviews in this particular study and the analysis of the themes and repeating juror perspectives suggest data saturation was achieved.

Results

During the study, a set of questions was asked which specifically related to the jurors' perception of the forensic science witnesses. These included both survey (Appendix A) and interview questions (Appendix B). The purpose was to elucidate responses which would provide

information relating to how the jurors' valued both the expertise and experience of the expert and to seek information on factors which might influence their perceptions of the expert's credibility.

Jurors' Definition of an Expert Witness

The jurors defined an expert witness in multiple ways but many definitions contained common descriptors such as '*knowledgeable*' and '*specialized*' and as someone who had '*received training*'. A few jurors indicated that a certain amount of experience was necessary to truly be considered an expert witness. "Justin" described a forensic science witness as:

"Somebody ...who has training. To me it's important to have a college background, scientific background. If you're going to be analyzing data, you need to understand statistics and also processes and knowing what procedures are and following them. Just because somebody takes a six weeks course doesn't really, to me, qualify them as an expert."

and "Gail" described experience as important:

"somebody with a lot of experience, has been working in it for quite a while".

For some jurors, credentials and certifications were an important part of the definition of an expert witness. "Gillian" expected forensic science experts to have:

"licenses or certifications pertaining to that field"

and "Matthew" said experts should have:

"credentials or certificates of competency".

Qualifications, Training and Certifications of an Expert Witness

One question on the survey question (Appendix A, question 4) asked jurors (n=25) to rate, in order of importance the qualifications and background criteria for an expert witness. The results combined across all 25 jurors are presented in Figure 3.

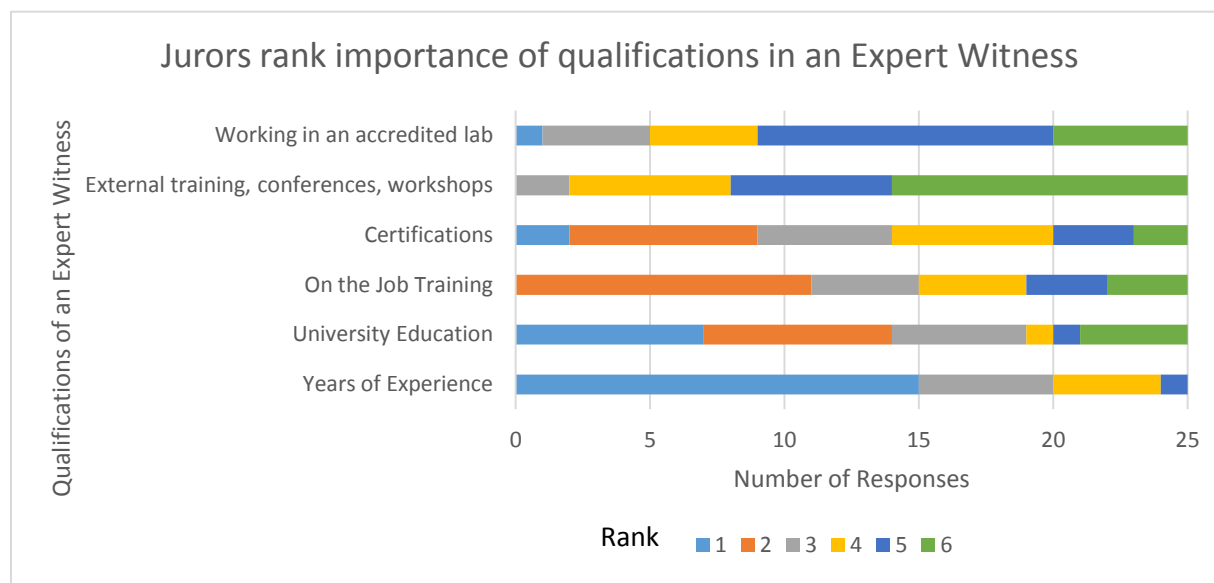


Figure 1: Jurors' interpretation of the importance of qualifications in an expert witness (Rank: 1= Most Important, 6= least important)

There was no one qualification that all jurors found important. Years of experience was ranked in the top 3 by 80% of the jurors, university education was ranked in the top 3 by 76% of the jurors and on the job training was ranked in the top 3 by 60% of the jurors. Less important to the jurors was whether the expert worked in an accredited lab or the expert's external training. 80% of the jurors ranked "working in an accredited lab" in the lower three positions and 92% of jurors ranked external training in the lower 3 positions. (Table 1).

Table 1: Importance of qualifications in an expert witness

Rank in importance	
Most	Least

	1&2	3&4	5&6
University Education	14 (56%)	6 (24%)	5 (20%)
On the Job Training	11 (44%)	8 (32%)	6 (24%)
Certifications	9 (36%)	11 (44%)	5 (20%)
Years of Experience	15 (60%)	9 (36%)	1 (4%)
Working in an accredited lab	1(4%)	8(32%)	16(64%)
External training	0	8 (32%)	17 (68%)

(red = below 25%; orange= >30-59%; green =>60%)

The data may have been influenced by the jurors' perceptions of higher education, where over 80% ranked experience and education high irrespective of whether they themselves had attained education beyond the high school level. A univariate analysis was calculated for university education and years of experience using a Spearman Rho correlation coefficient. There is moderate inverse correlation between a juror's ranking of university education and their ranking of years of experience ($r = -.637$, $N=25$, $P=.01$). Jurors who tended to rank university education high also tended to rank years of experience low, and vice versa. This data is illustrated in Table 2.

Table 2: Correlations of the ranking by Jurors of an expert witnesses qualifications

	University Education	On the job training	Certifications	Experience	Working in an accredited lab	External Training: Conferences/ workshops
University Education	1	-.190	-.031	-.637**	-.301	-.097
OJT	-.190	1	-.531*	-.036	-.020	-.029
Certifications	-.031	-.531**	1	-.321	-.209	-.046
Experience	-.637**	-.036	-.321	1	-.108	.055
Working in an accredited lab	-.301	-.020	-.1209	-.108	1	-.362
External training: conferences/ workshops	-.097	-.029	-.046	.055	-.362	1

****Highlighted areas indicate correlations which are significant at the 0.01 level (2-tailed)**

The same was true for the correlation between on the job training and certifications ($r = -.531$, $N = 25$, $P = 0.01$). Jurors who ranked on the job training high tended to rank certifications low. This appears to indicate that jurors either put weight on formal education of the expert witnesses, such as certifications and university education and placed less value on the job training and years of experience, or vice versa.

In response to the interview question “Which is more important in an expert witness, qualifications, such as education or certifications or years of experience?” (Appendix B, question 3) the majority of jurors, 63%, stated that years of experience was more important in an expert witness than qualifications (Figure 4) supporting the data derived from the paper survey.

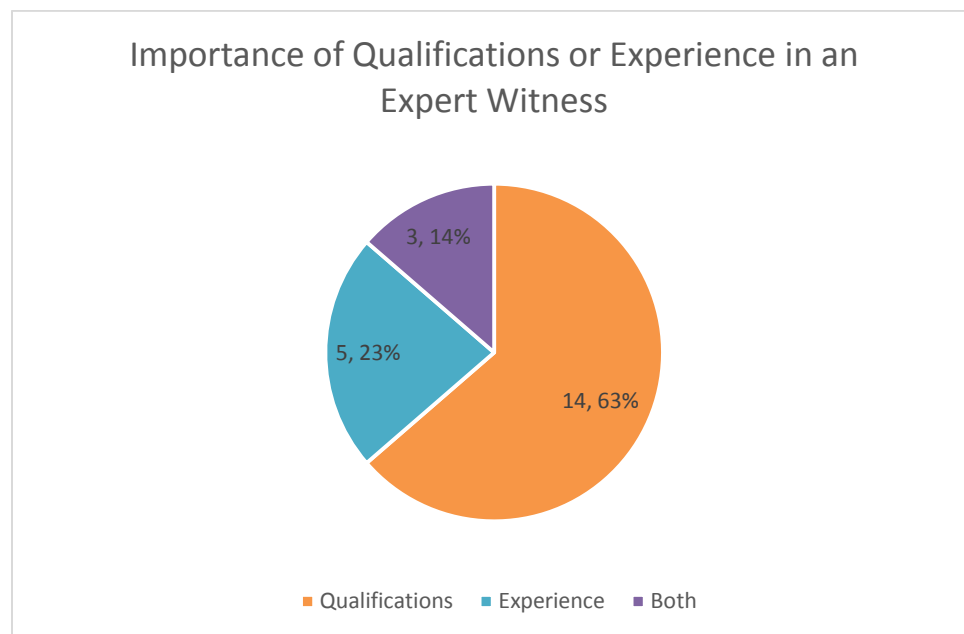


Figure 2: Jurors’ evaluation of the importance of formal qualifications vs. years of experience

Jurors thought experience was the most important factor in an expert witness and explained that although education and certifications are important for a forensic scientist, they

felt that it was the application of this knowledge (through job experience) that led to expertise. “Amy” stated:

“I think there are some people who can get many certifications and take many courses and classes, but they can't actually apply it and have never applied it. I think there are people who have developed significant experience in the subject matter from just seeing, doing, being around it, being around other people”.

Jurors described the value of experience in terms of the variety of evidence types a forensic scientist might be called on to analyze. “Amy” said that a person with experience would be better than a person with only qualifications when the evidence was complex or outside of what might be expected:

“(forensic scientists) having a sense of what the norm would be and things that would not necessarily be the norm.”

“Dana” described the benefit of experience to the forensic scientist as:

“Highly qualified people do not necessarily have the vast experience to know what is average or extraordinary or usual”.

“Dorothy” felt experience allowed the scientist a range of approaches when examining evidence:

“because every case is a little bit different, and I think that there's more flexibility in experience. (Evidence is) not as standard as stuff you get from the textbook”.

Some of the jurors related the value of experience back to their own professions and job experience. There was an understanding among jurors that forensic science as a profession cannot be learned solely from books. “Lloyd” said;

“I’m an accountant. When I started accounting, even though I had learned all this stuff, actually seeing it in practice the first time ...things are a little different than what you see in the book. You have to be able to recognize that. I would say that experience is probably, with the proper qualifications or the training, experience would be more important than the qualifications”.

“Larry” explained the value of experience by relating it to a life event:

“I would say years of experience, and here's a good example. My wife was seeing a medical specialist and saw him for several years, and he had qualifications. He had certificates and he had fancy diplomas, and he lost his medical license because he didn't know what ... he was doing. I would much rather, someone in a very serious professional field, I would much rather have someone that had a lot of experience and was competent.”

The challenge for new forensic scientists in qualifying as an expert in court will be to describe their qualifications and also how they have learned the discipline through supervised casework or other internal training. “Harold” explained:

“For example, if someone were soon out of college, I don't know that they're going to be an expert witness but they do have the necessary education to get them there. Some of those things go hand in hand. Experience is very important but their upbringing or background enters into it as well. I would think that a journeyman so to speak would be working with an expert witness and would become an expert witness over time based on both education and then experience in the career.”

A few jurors described the connection between experience and qualifications. To gain experience you need qualifications and to gain credentials you need experience. Certification in many of the different forensic science disciplines requires the scientist to have a certain

minimum number of years of experience, so it is true that credentials such as certifications require experience as well. “Ann” said:

“it’s hard for me to almost differentiate them because my assumption would be if they’re credentialed in anyway, that that process means that they do have experience. I guess I would say credentials, assuming that that comes along with some kind of procedure, or protocol, before they are credentialed that would involve experience.”

“Gillian” also felt that experience and qualifications went hand-in-hand:

“I think it varies because, well, personally I say both in order gain the qualifications you have to have the experience”.

For the most part the jurors valued both experience and the formal qualifications of the expert witnesses. “Grace” described why she thought both education and experience were important in an expert:

“I think both are important but a person wouldn’t be reliable if they didn’t have the proper qualifications and I think that’s just the standardized way of demonstrating someone’s expertise in the field is usually if they have a certain credential there. They’re passing the test but they’re also certified at that level by having years of experience. Someone doesn’t just pass the test and become a Medical Examiner. They’re supervised and they’re given feedback. To me, the qualification supersedes experience because it includes experience.”

When speaking of the importance of qualifications jurors focused on the value of foundational knowledge needed by a forensic scientist that the jurors described should be based

on education and other credentials. “Justin” described expertise in terms of his own experience as an engineer:

“I guess for me qualifications. I’m an engineer and the only way that I could get my professional engineering license was by having a certain number of years of experience. Then I’d have to have other professional engineers sign off that they’ve observed me and witnessed my performance. I’d have to have a certain amount of education in order to pass. I think qualifications is higher than experience”.

Judging the Credibility of the Forensic Science Expert Witness

Jurors were asked in the survey to rate the credibility, in their view, of the expert witnesses that they watched during the trial. The jurors who participated in the follow-up phone interviews were asked to describe how they determined if an expert witness was credible. Jurors rated all the expert witnesses they watched as being credible. Figure 5 illustrates the breakdown of the evaluation of credibility across all of the expert witnesses. 99% of the jurors felt that the expert witnesses were either very credible (54%) or Credible (45%).

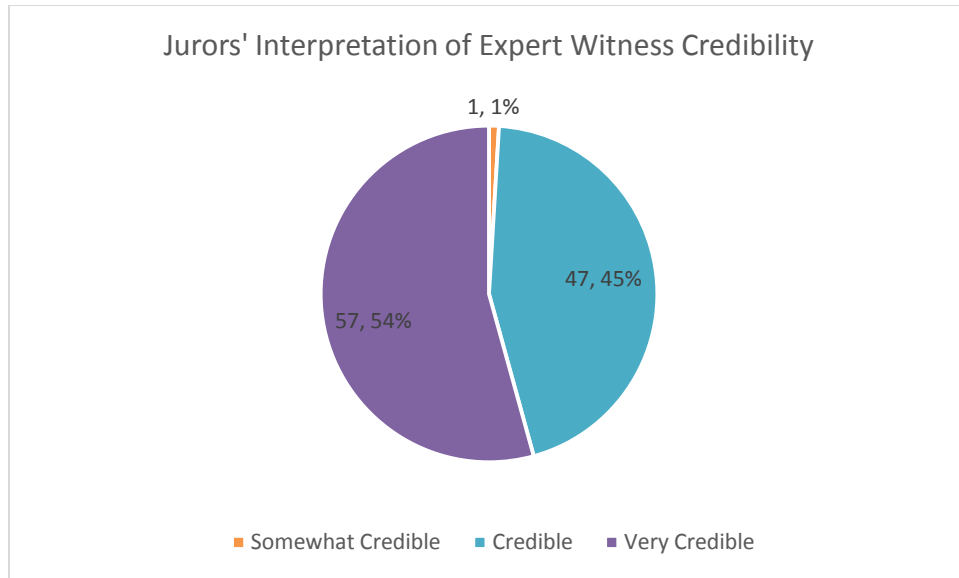


Figure 3: How jurors rated credibility of all expert witnesses who testified at their trial

Qualifications

Jurors described their view of the expert witnesses' credibility based on the experts' qualifications. Each time a forensic science expert witness testifies in the State of Maine they answer questions asked by the attorney who called them. This gives the court an opportunity to decide if the individual is an expert for the purposes of the trial. This process gave credibility to the expert witnesses. "Grace" explained:

"I believe that they were credible when they went through and introduced their background. They wouldn't just come up and start answering questions. They would begin by ... Well, actually it was from a question. The first question would be describing your background or qualifications or credentials. When they described that aspect, that's what sold me in trusting what they had to say."

"Lloyd" stated how he determined credibility of an expert witness as:

“the lawyers explain that, their background and their experience. We basically relied on that”.

“Barry” specifically commented on the testimony of the medical examiner:

"I remember specifically there was one guy, and I believe he was a doctor from the Maine State Crime Lab. The wounds that were inflicted to the victim, weren't self-inflicted..., I guess knowing he's a doctor, he had ... He gave his qualifications. He'd been working for the Maine State Crime Lab for a long time. I don't remember exact years, but I think knowing he obviously has hundreds of hours, I think that those are all important."*

*The medical examiner works for the Maine Attorney General's Office, not the Crime Laboratory.

Confidence and Demeanor

The most common reasons jurors gave to describe how they evaluated an expert witness' credibility was based on the expert's demeanor and their confidence on the witness stand. “Gillian” described how she based credibility on:

“their knowledge of fields and their confidence on the stand”.

“Gary” described the credibility in the same trial as:

“demeanor, I guess, to a degree. Good old fashioned judge of character. Sometimes the defense tries to get under their (expert witnesses) skin, so to speak, and you can see how people react, and you can see a seasoned veteran sometimes by that. I saw that first hand at the ...case.”

“Alana” commented on both prosecution and defense experts:

“You could tell the ones that were trying to just spin a line and the ones that were the honest ones and that were real sincere about their job and or the ones that were trying to avoid [sic] the answering (the question).”

“Justin” described how confidence and credibility were connected to how well an expert could answer difficult questions;

“It does influence your perception of the person, how they come across, if they’re back tracking or they’re tripped up by the lawyer and try to answer it, instead of just saying I’m not sure about this or if it sounds like a contrived answer then that kind of sways my thinking about what the person (expert) is saying.”

Experts being put forth by the Government

Some jurors appeared to believe that credibility automatically applied to any expert accepted by the judge. “Grace” believed the expert witnesses were formally licensed as forensic scientists and as expert witnesses. At this time forensic scientists in the State of Maine are not licensed and the decision to allow an individual to testify as an expert rests with the judge alone.

“They (expert witnesses) were licensed by the State of Maine to do the work that they did.”

It is to be expected that jurors who are unfamiliar with the role of forensics scientists and the responsibility of the judge as the gatekeeper might place undue weight on the credibility of an expert just because they work for the government. “Justin” explained it as:

“There is a whole level of inherent trust that you tend to apply to someone who comes forward that is brought to the case from the government.”

“Matthew” expressed how he determined credibility:

“I think that if you are employed by the government of Maine, I'd like to think that they're only going to hire people that know what they're talking about.”

For many professions in Maine and across the United States, licenses and certifications are necessary to perform business. Examples include hairdressers, barbers, tax accountants, nurses and doctors. This is not the case currently for forensics scientists. “Larry”, and possibly others, inferred that since licenses required in other industries, forensic scientists were also licensed.

“I would have to first feel comfortable that the party introducing them to me is credible and then that I have trust in whoever is coming. I work in a field, here in my job where an engineer puts their stamp on something, they're speaking on behalf of an industry standard or whatever. They're actually liable personally for what they're saying. I would hope that if we had an expert witness talking about whatever, I heard all kinds of them. I guess, myself knowing industry standards, I would make the, and I hate to use the word assumption but I will, assumption that they're speaking on behalf of their field of expertise and I would like to believe that they are offering credible information rather than tainted information. The experts were acting as representatives of the state of Maine rather than some private hire for the gun industry, or something. My opinion was that they had to be credible to serve doing the functions they were for the state.”

How the Expert Witness Explained the Evidence

Many of the jurors explained that credibility was tied to how the expert witness explained the evidence they were called to testify about. Expert witnesses know it is important to make sure the scientific evidence is accessible and understandable to the lay juror. This brings to light the fact that the ability of the expert to explain the scientific evidence is tied to credibility in the juror's mind. "Martin" explained credibility this way:

"as they have a conversation about their area of expertise, how did they explain it? Were they explaining in a way that they had a command of the information and yet they could explain it to lay people and the jury in a simple way?"

"Gregory" explained credibility in almost the same manner:

"I think their ability to explain ... On the scientific side of it, their ability to explain what they're talking about in layman's terms."

The jurors expect the expert witness to present in a clear manner and also expect the testimony to be engaging. "Harold" stated that credibility was based on:

"how they come across, their personality. Some people can be experts and be very rigid and stuffy and whatever and other people have come across quite naturally and I think that's a part of (credibility)".

Style of Testimony and Definitiveness of Conclusions

During the interview jurors stated that they appreciated when the expert witnesses used visual aids (forensic pathologists, fingerprint examiners, physical match examiners and tool mark examiners). The forensic pathologists used traditional poster presentations. These posters

explained where particular wounds were documented on the victim's body. The tool mark, fingerprint and physical matching experts used PowerPoint type displays to help explain their conclusions.

"Harold" commented that he based the credibility of a tool mark examiner on her style of testimony where she demonstrated a comparison between a wrench and a skull fracture:

"She was able to show that she believed that one fracture was caused by the front of the wrench, one was caused by the back of the wrench and one was caused by the side of the wrench where you could actually see the threads from the adjustable screw. I was totally impressed with that woman, but she did say...she couldn't say beyond a shadow of a doubt that that was what happened. She just blew me away and then I just believed the woman."

"Martin" also described that a visual display of the evidence lent to the credibility of the testimony:

"the visualality (sp) of that evidence. What I mean by that is the forensic team explained and did a 360 degree visual pictures of everything".

"Damon" described the presentation of the evidence at the trial as being very important to him in determining the credibility of the testimony of the medical examiner who testified about a gunshot wound in the victim's body:

"a picture of a neck and then (he) showed that going through it at this angle and then draw it in one more view, of the front view, then you could get the idea where that was going through."

"Justin" explained that the credibility of a crime scene examiner depended on how he demonstrated the evidence found at the entry point (on a door) in court:

"Justin": *This is a simple example, but they showed the backdoor before they took it off and they actually had brought the door to the evidence room. You could see that some markings were the same and it wasn't just a person*

saying that. The door was also a picture on the home that kind of backed it up.

Researcher: *They brought the door to the court?*

“Justin”: *Yes, they did, yeah. They showed us the knife marks and stuff.*

Researcher: *Okay. My next question is ... Sorry, go ahead.*

“Justin”: *For me it takes more than just someone’s word to incriminate somebody to make it a fact.*

In reference to a homicide scene where bloodstains were found in multiple rooms of the home and the defense put forward a theory that the defendant was acting in self-defense “Matthew” described how he based the credibility of a blood spatter expert on their ability to explain the blood stain patterns found at the crime scene through verbal testimony and the use of crime scene photographs.

Researcher: Okay. Perfect. What makes you think an expert witness is credible? If you think back to the trial, when you saw the scientific witnesses, how did you know if they were credible or not?

“Matthew”: Well, that's a good question. I guess I can use this one as an example. They had blood spatter ... What's the term ... But those that specialize in blood spatter, so they can tell which way a blade (of a knife) was being thrown, forward or backward or what, and I guess just, in general, science has proven that to be true, the way that they present it to you.

When forensic scientist’s testified about the evidence it was clear that some expert witnesses developed more of a rapport with the jury than other witnesses. When the expert witness played more of an educator’s role and took the time to teach the jurors a little about the science and how they came to their conclusions the jurors appeared to be more engaged. Jurors nodded their heads, made a lot of eye contact with the expert and

looked at their fingers during the testimony of the fingerprint experts. “Amy” described how she determined if an expert witness was credible:

“I think being confidence, being able to answer questions in detail, and being able to bring it down to a level for other people to understand it. I think almost like teaching, people who have a good knowledge base of the subject matter are able to look at their audience and teach the subject. Some people who just spout off key phrases without being able to explain or having any knowledge about detail I think tend to not be as credible as other people who have more subject matter detail”

Jurors mentioned that they did not understand DNA evidence and that this lack of understanding may have influenced their overall rating of the witness’s credibility. The footwear and tire mark evidence experts testified to class characteristics associations and not individualizations or ‘matches’. They testified that the crime scene impression(s) and known shoes/tires had the same pattern but could not be more specific in their conclusions.

“Charlotte” stated:

“The tire tracks, I think that it is more difficult, it’s not always clear cut, if it actually was the specific tire”.

Figure 6 illustrates the spread of jurors’ rating of expert witness credibility across the disciplines. Apart from the fingerprint examiners, all of the other expert witnesses were rated very credible or credible by the jurors.

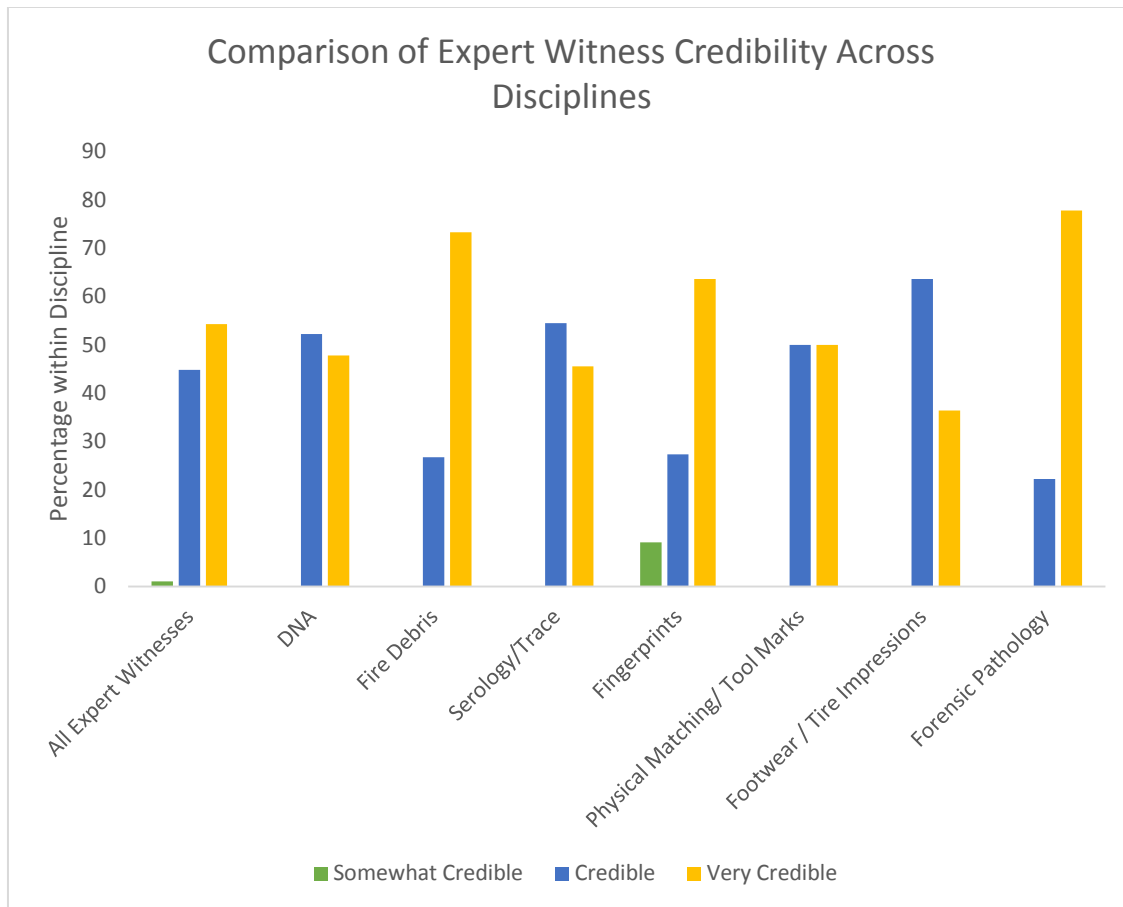


Figure 4: Jurors' Interpretation of Expert Witness Credibility

Conclusions

The jurors in this study defined expert witnesses as “knowledgeable” and as people who had received “specialized training”. When asked to rank qualifications of an expert witness, more jurors ranked experience in the specialized area as “most important” than those who ranked university education as “most important”. On the job training and certifications were slightly less important to the jurors and of least importance were continuing education such as attending workshops and conferences or whether or not the laboratory the expert worked in was accredited. This research is consistent with other studies which found that jurors place a lot of weight on the expert’s experience (Koehler et al., 2016, Blackwell and Seymour, 2015, Swenson et al., 1984, Schweitzer, 2016) and that university education is slightly less important to them (Schutz, 1997, Cooper et al., 1996). Many of the jurors stated that they believed both were very important.

These findings may be important for crime laboratory management and those who hire and retain scientific experts. If jurors place a lot of weight on the experience of the expert, then forensic scientists with only a few years' experience will have to highlight their other qualifications (e.g. on the job training, certifications and university education) to the jurors when qualifying as an expert.

Currently, the United States Federal government is moving forensic science towards universal standards in processing methodologies, conclusions and ultimately to national credentials for forensic scientists. These are important steps in promoting quality in forensics science, but jurors are evaluating the expert witness on their experience and expertise. In the future laboratory accreditation may be necessary to apply for and secure federal funding. While these policies and procedural changes are a step in the right direction for forensic science it is very important to keep the jury in mind. This research suggests that expert witnesses should make jurors more aware of the benefits of laboratory accreditation and continuing education of expert witnesses.

The credibility of an expert witness can be defined as how persuasive that person is when they give testimony (Ivkovic, 2003, Pope et al., 2006). Pope suggests that credibility is related to the expert's "authoritativeness, character, competence, attractiveness and expertness" (Pope et al., 2006). Understanding how jurors interpret witness credibility is important as it has been shown to influence perceptions of evidence reliability and verdicts (Cramer et al., 2009, Ivkovic, 2003). This research supports the previous studies which identified likeability, believability, trustworthiness and intelligence as being the main factors which influence jurors' perceptions of forensic science expert witnesses (Brodsky et al., 2010). In this study the jurors described that the expert's confidence and demeanor when testifying were the most important factors in determining their credibility as a witness. Jurors also used the number of years' experience the expert witness had gained, as well as their qualifications, to establish credibility. Sometimes prosecution or defense lawyers will offer to stipulate to the witness's expertise to save time during the trial or to minimize their ability to gain credibility with the jury. This research indicates that the process of qualifying an expert before testimony about the evidence begins is a necessary and very important for the expert and the jury.

Of some concern to the justice system may be the responses from jurors who based the expert witness's credibility on the fact that they were governmental employees or that they were presented by a prosecution attorney. Defense attorneys need to be aware that jurors may place additional confidence in experts employed by the government and may choose to highlight that history had shown that governmental laboratories do make mistakes (Garrett and Neufeld, 2009).

This study supports previous research which indicates that experts appear more credible to the jury when they take the time to teach the jury about how they came to their conclusions and supported their testimony through the use of demonstrative aids (Rosenthal, 1983, Gutheil, 2000, Blau et al., 2017). If the evidence or the expert's conclusions can be demonstrated using a visual aid this will likely aid the jury's understanding and in turn increase the perception of the expert's credibility.

The results of this research were based a narrow sample of jurors (Maine jurors, called by the prosecution in homicide trials) and caution needs to be exercised with how these results reflect on jurors in general. This type of research on real jurors observations of forensic science testimony should be repeated and consideration given to experts called by the defense and trials where the defendant is charged with a lesser offense. Every effort was taken to minimize researcher bias but it is a concern in all qualitative studies. The coding of the data by the researchers may have influenced the interpretation of the results and as such further research in this area is needed.

Due to the size of the sample, all jurors who responded to the request to participate in the research were included. This self-selected, non-randomized, population of jurors may not represent jurors as a whole. Research involving post trial surveying and interviews of jurors will always have limitations. It is very difficult to get the perfect sample that can represent the greater population. These limiting factors should be considered when applying these results to other populations and circumstances.

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Appendix A

Please answer the following questions about yourself and the trial where you were a juror or alternate.

1. What is your gender?

- ☐ Male
- ☐ Female

2. How old are you?

- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-54
- ☐ 55-64
- ☐ 65+

3. What is the highest level of education you have completed?

- ☐ Less than high school
- ☐ High school/ GED
- ☐ Some college
- ☐ Two year college degree (Associate)
- ☐ Four year college (BS or BA)
- ☐ Master's degree
- ☐ Doctoral degree

4. List in order of importance (6= least importance, 1= most importance) the most important qualifications of an expert witnesses

<input type="checkbox"/>	University Education
<input type="checkbox"/>	On the job training
<input type="checkbox"/>	Certifications
<input type="checkbox"/>	Years of experience
<input type="checkbox"/>	Working in an accredited laboratory
<input type="checkbox"/>	External training, such as conferences, workshops

5. With regard to (insert Expert witness name and brief description to the content of testimony) how credible (believable) was his/her testimony?

- ☐ Not credible
- ☐ Somewhat credible
- ☐ Credible
- ☐ Very credible

6. How effectively did the (forensic scientist e.g. firearms examiner) explain to you how he/ she came to his /her conclusions?

- ☐ Poor Job
- ☐ Fair Job
- ☐ Good Job
- ☐ Great Job

7. Did the chart/ demonstration/ media presentation help you understand the subject matter (e.g. bullet trajectory?)

- ☐ Not at all
- ☐ To some extent
- ☐ To large extent

Appendix B

Phone interview questions

1. I would like to go back to one of the questions on the paper survey, the question stated list in order of importance the qualifications of an expert witness, University education, on the job training, certifications, years of experience, working in an accredited lab and external training such as conferences/workshops. Ask juror to confirm their order that they put on the paper survey

2. Ask them to define what an expert witness is then ask: What makes you think an expert witness is credible?
3. Which is more important in an expert witness qualifications or experience and why?
4. Did you feel that you didn't understand any of the scientific evidence and if so what would have helped?

Figure 3
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Figure 4
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Figure 5
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Figure 6
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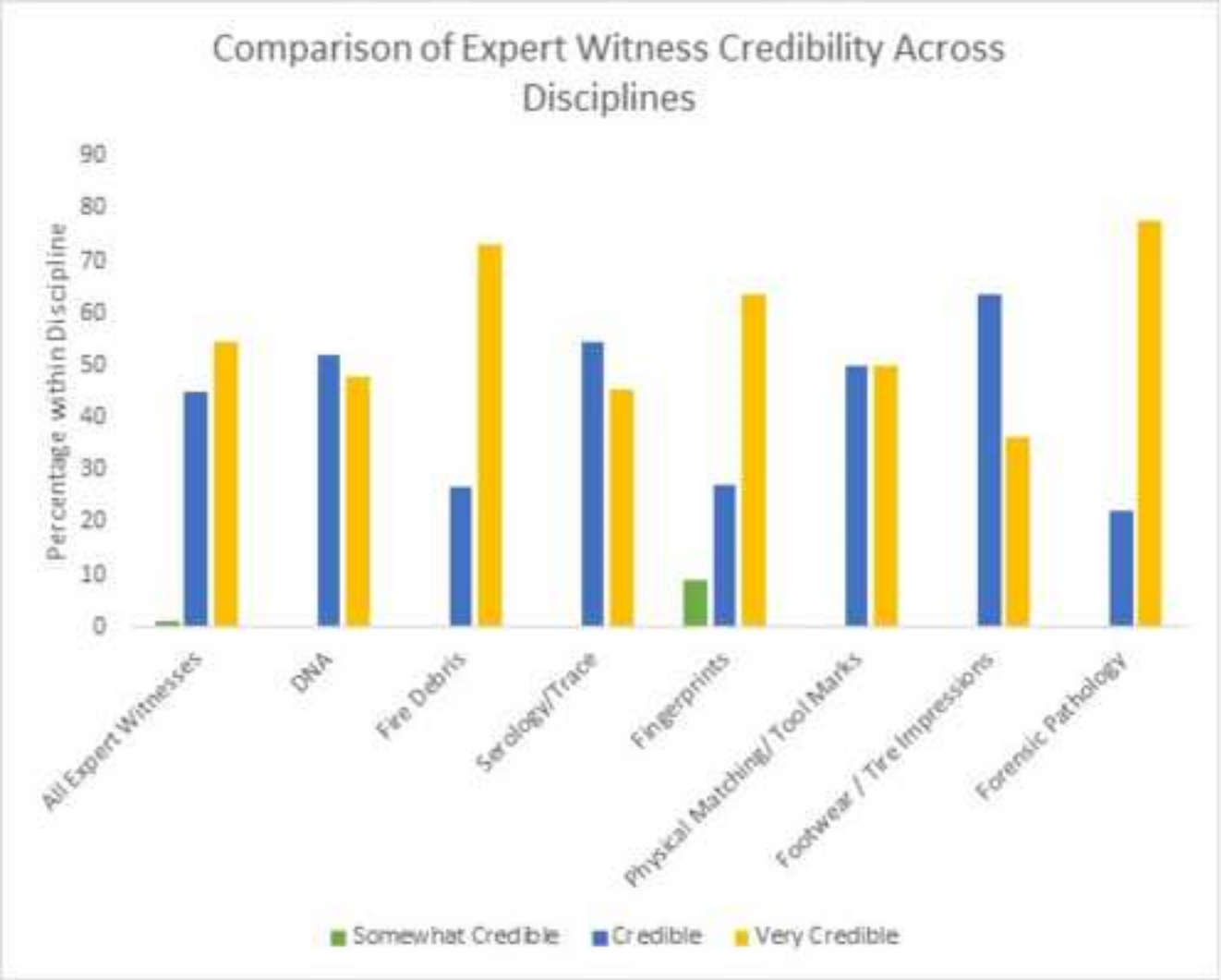


Figure 1
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Figure 2
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Table1

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	Rank in importance		
	Most		Least
	1&2	3&4	5&6
University Education	14 (56%)	6 (24%)	5 (20%)
On the Job Training	11 (44%)	8 (32%)	6 (24%)
Certifications	9 (36%)	11 (44%)	5 (20%)
Years of Experience	15 (60%)	9 (36%)	1 (4%)
Working in an accredited lab	1(4%)	8(32%)	16(64%)
External training	0	8 (32%)	17 (68%)

(red = below 25%; orange= >30-59%; green =>60%)

Table 2

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	University Education	On the job training	Certifications	Experience	Working in an accredited lab	External Training: Conferences/ workshops
University Education	1	-.190	-.031	-.637**	-.301	-.097
OJT	-.190	1	-.531*	-.036	-.020	-.029
Certifications	-.031	-.531**	1	-.321	-.209	-.046
Experience	-.637**	-.036	-.321	1	-.108	.055
Working in an accredited lab	-.301	-.020	-.1209	-.108	1	-.362
External training: conferences/ workshops	-.097	-.029	-.046	.055	-.362	1

***Revision Notes (Response to Reviewers)**

Issue/suggested change	Action/ Remedy	Page number
Reviewer #1		
1) <i>Introduction</i> : The literature review is brief, but does a creditable job of laying out relevant findings from previous studies. It would be useful to conclude the introduction with the set of research questions or hypotheses that the study was designed to address.	<p>The literature review was amended to include more background to previous research and to update the sources to include more recent publications</p> <p>A research questions was added to the end of the introduction</p>	<p>2-3</p> <p>3</p>
<p>2) <i>Methodology</i>: The method section gives far too few details about how the study was conducted. Figure 1 that provides an overview of the research design is presented without explanation. What is “a parallel convergent exploratory mixed methods design” and why was it chosen?</p> <p>3) The authors do not provide any information on where the study was done, what type of court and cases were the jurors drawn from, and how the jurors were selected for participation. The authors include the survey and phone interview in appendices. However, it would also be useful to characterize the items contained in each in the body of the article.</p>	<p>Figure two was explained further and the reason this method design was chosen was clarified</p> <p>The methods section was enhanced considerably. Far more information was added on the participants, the data collection and the analysis of the quantitative and qualitative data.</p> <p>The paper is already lengthy. The authors feel the flow would be interrupted if any more of the survey/interview questions were in the body of the article. Some questions are already mentioned where appropriate.</p>	<p>Page 7</p> <p>5-8</p>
4) <i>Results</i> : The section presenting jurors’ definition of an expert witness contains numerous quotes from individual subjects. It would be better started by a brief summary of their views, using a few examples to highlight the summary.	This suggested change (a summary of the jurors perspectives rather than presentation the juror’s perspectives with quotes) needs to be balanced with reviewers 2 and 3 questions of robustness (in their comment #13). A summary of the responses has been given and comments by Harold, Martin, Alana and Barry have been removed.	Page 9
5) I would replace Table 1 which depicts the individual responses of the 25 subjects with a summary of the average rating for each of the six qualification types. Table 2 seems redundant with Table 1.	Because the sample is small, only 25, information is lost when averaging the data. Table 1 was removed.	

6) I don't understand the paragraph on p.8 which reads, "The data may have been influenced by the jurors' perceptions of higher education, where over 80% ranked experience and education high irrespective of whether they themselves had attained education beyond the high school level."	This was removed	
7) The sentence on p. 8 that reads, "This data is illustrated in Table 3 and Figure." Is incomplete. I assume the authors meant to say Figure 4?	This has been fixed	11
8) I don't understand the purpose of Figure 3 that displays responses of individual subjects by categories of experience and education. Where is it discussed in the text?	This table was removed as it was confusing	
9) The sectors of the pie chart in Figure 4 don't sum to 100% -- it looks like the figure is based on raw numbers of cases rather than percentages.	They do add up to 100. Both the percentages and raw numbers should be visible to the reader.	Page 12
10) The figure on p.15 does not have a number.	This has been fixed	17
11) Too many quotes on confidence and demeanor are included on p.17. Better to start with a brief summary of their views and use a quote of two to illustrate. 12) Too many quotes on how experts explained the evidence on pp.19-20.	Again balancing this comment with reviewers 2 and 3 highlighting additional information on robustness. One of the methods of assuring robustness in qualitative research is the inclusion of many raw quotes. There are only 4 quotes for each "confidence and demeanor" and on "how experts explained the evidence". The value in qualitative research is based on the illustration of the data and the authors believe the 8 quotes here should remain.	
13) Are the bar charts in Figure 5 on p.22 based on the whole sample of 25 cases?	Yes, based on 29 jurors who filled in the survey	Now labeled Figure 6 on page 24

Reviewers 2 and 3		
1. We highly recommend that the investigation be reported following the COREQ guidelines:	See comment 4, below	
2. The abstract is a succinct description of the research and well structured. However there are some typos and grammatical mistakes that affect readability and comprehension, e.g: "were move favoured over..." instead of "more favoured".	These grammar issues have been fixed	1
3. The introduction (first paragraph and last paragraph) exposes clearly the study's justification. Nevertheless, the literature appears outdated (most recent study cited is from 2010) and no explanation is provided for this. Similarly, it is unclear whether there are previous studies into the factors selected, e.g: the role of education, years of professional experience, and qualifications on jurors' perception of the witness.	The literature review was amended to include more background to previous research (the role of education, experience and other factors in influencing jurors perceptions of experts) and to update the sources to include more recent publications	Pages 2-3
4. The paper reports its methodological contributions and adequately sustains them by referencing other studies. In addition, the use of a mixed method design is fit-for-purpose, yet not clearly exposed. However overall it is significant weak section as their method process is extremely under reported. Unfortunately relevant methodological information is lacking to critically evaluate the study and its robustness. The guidelines for qualitative research reporting are outlined in: Allison Tong, Peter Sainsbury, Jonathan Craig.	The methods section was enhanced considerably. Far more information was added on the participants, the data collection and the analysis of the quantitative and qualitative data. The authors followed the COREQ guidelines and included nearly all the suggested items on the COREQ checklist in the methodology section.	Pages 3-7

Consolidated criteria for reporting qualitative research (COREQ):		
5. Figure 1 describing the method procedure was deemed helpful, but the last box (Interpret Quant and Qua)l was found confusing.	Figure 1 is now Figure 2 Figure two was explained further and the reason this method design was chosen was clarified. The “interpret qual/quant” in the diagram just means that the results are interpreted and conclusions formed.	7
6. Reporting of Pearson correlation coefficient findings (page 8) needs to be improved by reporting the intensity: e.g. "A moderate inverse correlation was found between a juror's ranking of university etc)	This was fixed	
7. Please refer paragraph 1 regarding the interpretation of Pearson correlation between certification and on the job training. There is a discrepancy between the Table 3 data ($r=.511$) and what is later reported ($r=-.511$), affecting the direction of the relation. The sentence: "The same was true for the correlation between on the job training and certification" warrants attention" could be misleading. The previous correlation was a moderate inverse correlation, and the one being explained is moderate direct (data from the table). The paragraph content is affected by this discrepancy. If an error in data reporting is found then the abstract, discussion and conclusions requires revision.	The column was too narrow and the minus sign was above the number. This has been fixed and there is an inverse correlation.	
8. Qualitative data findings There should not comparison with the literature in this section. The appropriate place is the discussion section.	This was moved to the discussion	

9. Page 18. The authors state "of some concern to the justice system may be the response from jurors who based the expert witness credibility". This statement warrants further development, and might be better addressed in the discussion.	This part was moved to the discussion and conclusions section	
10. Page 20. Last two paragraphs refer to the interpretation of Mathew's answer and his quotations. However it was unclear for me what exactly is the finding.	This was modified and move to the next section	Page 22
11. Findings regarding Style of Testimony and Definitiveness of Conclusions: The first two paragraphs report findings but there is no data to sustain their claims. (We suggest an annex with a table of quotations should be submitted) The qualitative data findings are detailed and extensive.	This area was enhanced with additional juror responses	PaGE 21-23
12. Some figures are missing their numbering (pg. 15) or have incorrect numbering (pg. 22) and their referencing in the text appears to be erroneous (pg. 22).	These are fixed	
13. Discussion The study appears to provide rich and interesting findings (although it is difficult to evaluate their robustness). But the discussion section does not reflect to what extent the study's findings contribute to the existing literature. Once again it is too short. The	The detailed explanation of the methodology should give readers a sense of the robustness. The 22 phone interviews and an assessment that data saturation was achieved in the research also highlights the strength of the results. The limitations section added to the end gives the reader some of the weaknesses and need for future research.	

authors should move the "discussion of literature" in the finding sections to this section.	This area was enhanced and how this research fits with previous research was discussed	Pages 24-26
14. Conclusion The findings' limitations are not reported. As importantly the findings contribution requires further development.	The limitations of the study were added	Pages 26-27
15. References Review of the journal referencing style guidelines is recommended.	<p>The online “guide for authors state”</p> <p>There are no strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Where applicable, author(s) name(s), journal title/book title, chapter title/article title, year of publication, volume number/book chapter and the pagination must be present. Use of DOI is highly encouraged.</p> <p>The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage.</p> <p>I have left the reference style in Harvard format at this time.</p>	

***Revision Notes (Response to Reviewers)**

Issue/suggested change	Action/ Remedy	Page number
Reviewer #1		
<p>The method section remains underdeveloped (a single paragraph).</p> <p>It should indicate the methods used (survey and interviews - mentioned later in the Results section).</p> <p>It also should specify the type of court and cases drawn from,</p> <p>and how the jurors were selected for participation. With this minor change, I would recommend publication.</p>	<p>The methodology section is 12 paragraphs long and already contains all the information this reviewer is asking for.</p> <p>No action taken</p> <p>No action taken</p> <p>No action taken</p>	<p>Pages 3-7</p> <p>Survey and interviews are mentioned under “Data collection” on page 4.</p> <p>The type of court cases the jurors were drawn from is detailed under “Participants” on page 4.</p> <p>How jurors were selected is detailed near the end of the paragraph “Data Collection” on page 5</p>
Reviewer #3		
<p>The introduction clearly justifies and delimits the study. However, there are editing issues to be addressed, such as: unclear ideas (see Par 2. 3rd sentence), lack of synthesis and citation issues. Further editing and proofreading throughout the document is required.</p>	<p>The introduction was edited to make it stronger and highlight to the reader the importance of this piece of research. The whole paper has been proof read and small edits have been made to condense sentences and improve the flow.</p>	
<p>Methodology</p> <p>The revised version addressed many of the criticism of the first draft. However, it still needs further improvement for publication.</p> <p>The study design section should be at the start not at the end, and needs re-writing (Sentence 2 is unclear, sentence 3 is repetitive as it appears in section qualitative data).</p>	<p>The Research method was moved to the beginning of the methodology section and figures 1 and 2 were re-labeled</p> <p>Sentence 2 was edited and the</p>	<p>Page 4</p>

	section under qualitative data was removed as it was a repeat of sentence 3 in the research method section.	Page 7
<p>The following information is missing and requires reporting: response rates (Data collection or Participant section);</p> <p>questionnaire design (length, type of questions).</p>	<p>Response rate was added to the participant section and removed from the limitations section.</p> <p>No action taken</p>	<p>1st paragraph, page 5</p> <p>The survey is included in the Appendix and further describing the questions would break up the flow and add to the length of the paper, which the reviewer feels needs to be shorter</p>
<p>The author should also describe the statistical analysis methods selected: univariate analysis and correlations tests (criteria for undertaken correlations test should be explained), as well as management of missing data.</p> <p>I am unsure if the correct correlational statistical method for ranked based data was selected, in addition there are issues regarding interpretation of results. The acceptable measures of non-parametric rank correlations is Spearman's (rho) and Kendall's Tau. The results will be affected by sample size, which might be addressing in the limitations.</p>	<p>No Action taken</p> <p>The sample size was previously addressed in the limitations section and is now part of the conclusions</p>	<p>The term “univariate analysis” was added to the paragraph above table 2 on page 10</p> <p>Missing data was addressed in the “quantitative data” section on page 6</p> <p>Pearson's correlation is used to measure a linear relationship between two continuous variables and uses the actual values of the data.</p> <p>Spearman's rho ranks the data and then computes the correlation statistic and measures a monotonic relationship between the two variables, meaning there does not have to be a straight line relationship but the association should always be moving in the same direction or can level off, but it cannot change direction. Our data is already ranked - it is naturally ranked as that is how we collected the data. Just because someone uses ranked data does not mean you have to</p>

		<p>use a spearman correlation statistic. What determines which correlation to use is whether you believe your data follows a normal distribution and you are expecting a straight line association. Those are the two assumptions necessary to use a Pearson correlation. Our data it is naturally ranked and with a limited range so there are no outliers to worry about and thus it is safe to assume the data are normally distributed within the constraints of an ordered categorical variable (data has a limited ranged so it is not continuous data but ordered categorical data) - people treat Likert scales as continuous normally distributed data all the time and that the relationship between two ranked variables would be linear. A Spearman's Rho correlation was calculated for the variables and the results are the same as the Pearson Correlation used. See correlation results below.</p>
<p>Coding effect on interpretation of findings should be reported in the results sections.</p> <p>Finally interpretation of correlation values will be affected by data coding - is the highest rank "most important" assigned the lowest value 1, or is it assigned the highest value 6.</p>	<p>We believe that the reviewer is referring to the coding of the qualitative data here, rather than the quantitative data.</p> <p>The ranking of data and the use of likert scales were all consistent in the research. The survey was clear that 1 was the most important and this is reported in the paper.</p>	<p>Coding effects and steps to minimize are addressed on pages 6/7 under "qualitative data".</p> <p>The limitation section was incorporated into the conclusions section and the effects of researcher coding was mentioned as a limitation on page 26.</p>

<p>Editing would help shorten the text, allowing for missing information to be included, without burdening the reader.</p> <p>The long paragraph regarding sample size in qualitative research is not required. However, the reader does need to inform if data saturation was achieved.</p>	<p>Small edits made to this paragraph</p>	<p>This paragraph was added to the paper due to comments on validity by reviewers 2 and 3 in the first round of edits.</p>
<p>Fig1, first square text could be replaced by "Design of survey and phone interview guide" instead of Survey and phone interview questions finalized.</p>	<p>This was changed to the suggested language. This is now figure 2.</p>	
<p>First paragraph is unnecessary on page 7.</p>	<p>No action taken</p>	<p>In the first rounds of edits reviewer 1 asked "Methodology: The method section gives far too few details about how the study was conducted. Figure 1 that provides an overview of the research design is presented without explanation. What is "a parallel convergent exploratory mixed methods design" and why was it chosen?" This paragraph must remain to answer this question</p>
<p>Page 10 -11. As it is uncertain that the appropriate statistical test was performed, data needs revision.</p>	<p>No action taken</p>	<p>See explanation above on Pearson correlations, normal distributions and ranked data</p>
<p>Page 23 first paragraph after Mathew's quotation-interpretations are not sustained by data within the scope of the investigation. The researcher only declares : survey and interview as her data collection methods, although does inform in Fig1. "researcher observed expert witness". Therefore, comments such as; Jurors nodded their heads, made a lot of eye</p>	<p>The researcher's observations of the jury during the trials was added to the narrative on the methodology.</p>	<p>Page 5, 1st paragraph</p>

contact with expert and looked at their fingers during testimony of the fingerprint expert - are not sustained by the mentioned data collection methods. The authors has two options to: incorporate observation as a data collection method and provide all necessary details (proof of systematic collection of data through observations) in the methods section or eliminate such interpretation in the finding section.		
Page 23 Mathew's quotation is nearly exactly the same as on page 21. I am unsure how it contribute to this section.	Quotation on page 21 was removed.	
Qualitative data findings There should not comparison with the literature in this section. The appropriate place is the discussion section.	No action taken	There are no references to the literature in the results section
<p>Discussion and Conclusion The discussion section has definitely more substance than the original version. However, the author should draw more on the existing literature and literature citations are required.</p> <p>Limitations Response rate should be provided in the methodological section.</p> <p>As part of the limitations the author should reflect on sample bias of self-selected participants and the implication for generalizability and validity. The effect of sample size on correlation tests might require reporting.</p> <p>The author could also briefly expose what variables would be of further interest to explore, for example the</p>	<p>These suggestions were helpful and modifications to the conclusions section were made</p> <p>This has been removed from limitations and added to the methodology. See above</p> <p>This has been added to the end of the paper</p>	

study did not include any analysis of the relations of the juror's characteristics (age, gender, level of education, or profession) and their views regarding expert witness. They might want to describe this as a limitation or as part of their conclusion as possible future areas of study.	The conclusions section has been tidied up and suggestions for future research made.	
A limitation section or subsection is not a requirement of Elsevier's article structure outline. Therefore the limitations should be incorporated in the discussion section as a paragraph (at the start or the end of the section). Conclusion The articles published in this journal include a conclusion section or subsection	This has been amended A conclusions section already exists	

	University Education	On the job training	Certifications	Experience	Working in an accredited lab	External Training: Conferences/ workshops
University Education	1	-.190	-.031	-.637**	-.301	-.097
OJT	-.190	1	-.531*	-.036	-.020	-.029
Certifications	-.031	-.531**	1	-.321	-.209	-.046
Experience	-.637**	-.036	-.321	1	-.108	.055
Working in an accredited lab	-.301	-.020	-.1209	-.108	1	-.362
External training: conferences/ workshops	-.097	-.029	-.046	.055	-.362	1

Spearman's Rho correlation coefficients

Reviewer #3: This draft is an improvement to previous versions, however I have concerns regarding the reporting standards. Some weak sections are:

- a) Method in the Quantitative Method section- Apart from the information provided, the selection of statistical analysis (including tests) must be reported and justified. This was raised before. Some of the papers quoted in the introduction provide good examples on what must be described in the method section.

Additional information was added to the quantitative section on page 6. An explanation of the Spearman Rho test and why it was used was reported and justified.

- b) My concerns expressed regarding the choice of correlation test. The variables are being ranked in relation to the other variable (variables that are separately put in order and are numbered-). I am unsure you can treat it as an interval variable, with normal distribution, just as as one does with Likert scales. Ensuring we are using the right correlation is important for the quality of the paper. Please, can you provide examples of other research whereby Pearson's correlation was used for ranked data - variables that are put in order in relation to each other? (and not ranked by Likert Scale?).

To address the questions of interval variable/ ordinal data we decided to use the Spearman Rho test (as this reviewer previously requested). The conclusions remain the same.

- c) Several diagrams and tables do not satisfy reporting standards. Formatting consistency is required.

The above mentioned affect the paper's quality.

The diagrams and tables are all saved as TIFF files as required by the editor. It is our expectation that these will be modified for size and shape prior to publication.

CRedit author statement

Alicia Wilcox: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing- Original draft preparation. **Niamh Nic Daeid:** Writing- Review and editing, Supervision, Methodology, formal analysis